BBC WHEN TO SEE MARCH'S SOLAR & LUNAR ECLIPSES

#238 MARCH 2025

Sky at Night

THE UK'S BEST-SELLING ASTRONOMY MAGAZINE

PLUS How to watch and image the ISS passing overhead

MARS A NEW ERA

As NASA's rover enters unexplored territory, the story so far...

WHY WE NEED TO CHANGE OUR ADDICTION TO LIGHT

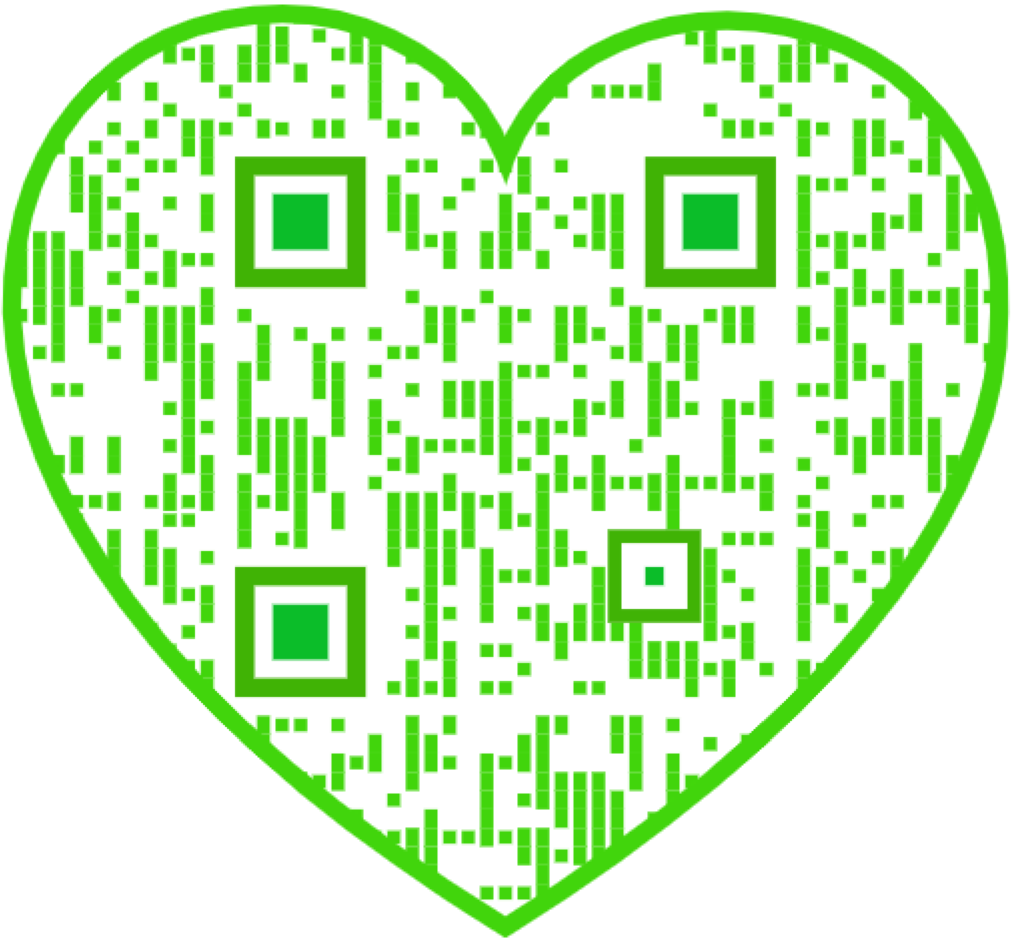
60 YEARS OF SPACEWALKS

Canon
EOS
R8

STAR TEST: CANON'S R8 MIRRORLESS CAMERA

WHY SATURN'S RINGS WILL DISAPPEAR THIS MONTH

THE NEW THEORY THAT COULD OVERTHROW DARK ENERGY



Perpetual lunacy

The extraordinary new **C1 Moonphase** from Christopher Ward. A watch that tracks the moon for 128 years – without missing a beat. With an aventurine glass dial infused with copper oxide to represent the night sky. And a 3D 'moon' sculpted from Globolight© – a luminous ceramic – that precisely follows the real moon's journey across the sky. A watch this advanced can cost up to £45,000. But the C1 Moonphase starts from less than £2,000. As someone once said, you don't have to be mad to work here...
Do your research.

Christopher
Ward

christopherward.com

SCAN ME

Welcome

Perseverance is ready for its next big adventure

Far from Earth, 140 million miles away in deep space, NASA's Perseverance rover recently reached a milestone. It completed a steep 500-metre climb to reach the rim of the Mars crater that it's spent the past five years investigating. Now, as new vistas open up for exploration, on **page 28** Stuart Atkinson charts the car-sized rover's journey so far and looks ahead to the scientific discoveries to come.

Perseverance's adventures are astounding to keep in mind as you look up at the Red Planet this month. It's still bright and relatively high after opposition in January, and by the end of March, as it moves earlier into the evening twilight, its salmon colour will make a beguiling sight set against the deep purple tones of the blue hour. It's an exciting month for stargazing, with a solar and a lunar eclipse on view as well, and the bright planets Mercury, Venus and Jupiter still visible. Turn to the Sky Guide on **page 43** to discover more.

For a growing number of us, the brighter planets are all that's visible in the night sky, a pale comparison to the majesty of truly dark nights. The cause is light pollution; as one scientist who monitors its rapid spread simply put it: "lighting up things that shouldn't be lit." On **page 66**, dark-sky advocate Paul Bogard considers why we seem to have stopped noticing the loss of our dark skies and reminds us that solutions are closer at hand than might at first appear.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Tuesday 25 March.

HOW TO CONTACT US

Subscriptions, binders and back issues
03330 162119*
Mon–Fri 9am–5pm

*Calls from landlines will cost up to 9p per minute. Call charges from mobile phones will cost between 3p and 55p per minute but are included in free call packages. If calling from overseas, please dial +44 (0)1604 973727

Editorial enquiries +44 (0)117 300 8754
9:30am–5:30pm, Mon–Fri
Advertising enquiries +44 (0)117 300 8803

Print subscription enquiries
www.ourmediashop.com/contactus
Digital subscription enquiries
www.ourmediashop.com/contactus
Editorial enquiries
contactus@skyatnightmagazine.com

Subscription enquiries
UK enquiries: FREEPOST OURMEDIA
(please write in capitals)
Overseas enquiries: PO Box 3320,
3 Queensbridge, Northampton, NN4 7BF, UK

Editorial enquiries
Please write to the Editor, *BBC Sky at Night Magazine*, Our Media, Eagle House,
Bristol, BS1 4ST

Become an Insider

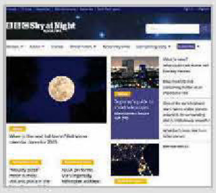
ourinsiders The more we know about what you like, the better placed we are to bring you the best magazine possible. So we'd like to invite you to join our exclusive online community. To get started, visit **ourinsiders.com** to fill out the short registration survey and we'll be in touch from time to time to ask for your opinions on the magazine and other relevant issues.

Sky at Night – lots of ways to enjoy the night sky...

The Sky at Night

Television

Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18

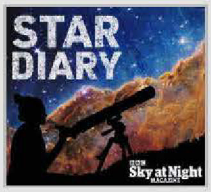


Online

Visit our website for space news, astrophoto galleries, observing guides and more

Social media

Follow us on X (formerly Twitter), Facebook and Instagram for the latest astro news



Podcasts

Discover the best things to see in the night sky every week by listening to our Star Diary podcast

Sky at Night
GRAVITY

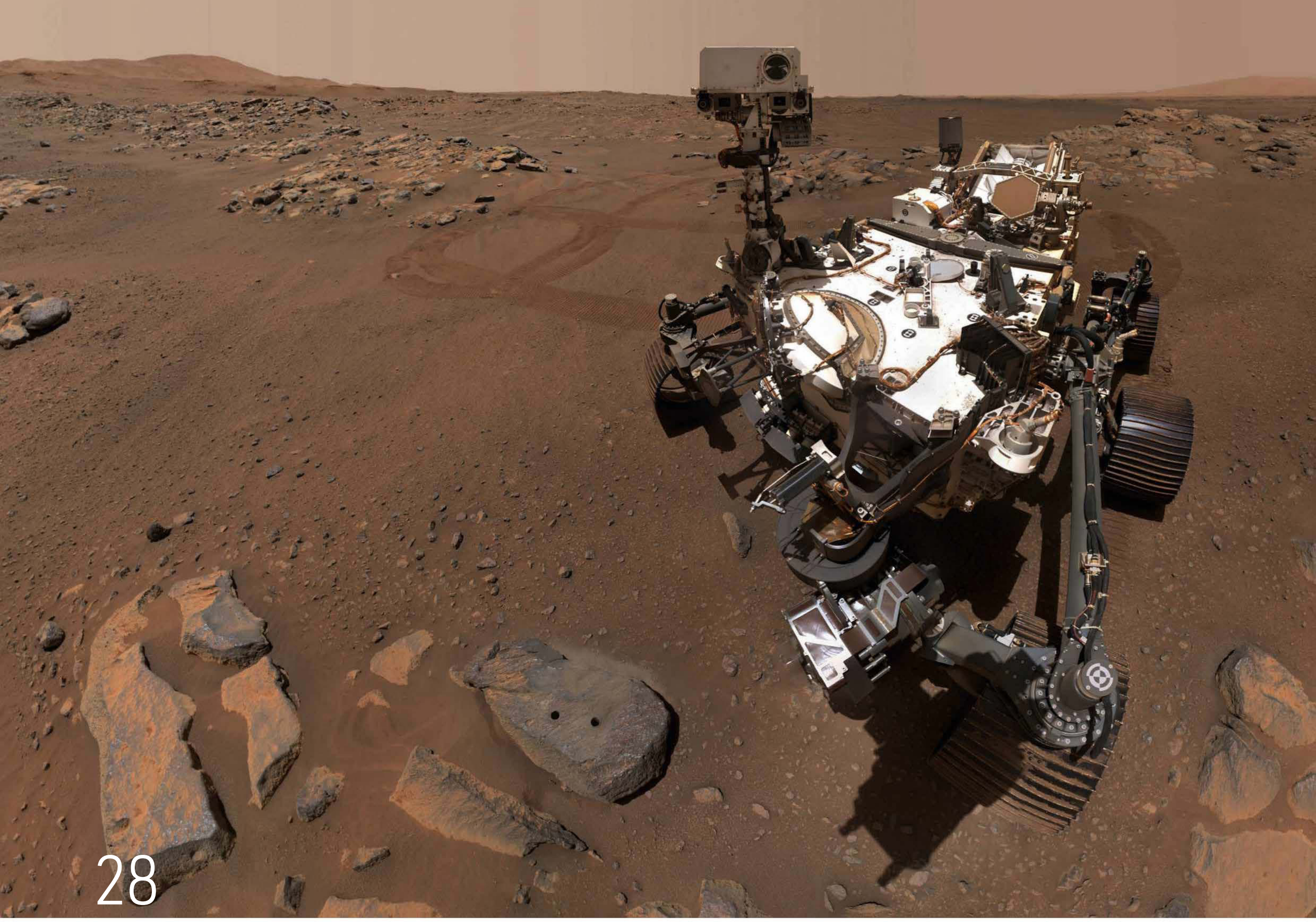
Tablet/phone

Get each month's issue on your Apple or Android device, now with bonus image galleries

eNewsletter

The best targets to observe each week, delivered to your inbox. Visit **bit.ly/skynewsletter**

Find out more at: www.skyatnightmagazine.com



CONTENTS

Ⓒ = on the cover

Features

28 Perseverance: the story so far
Ⓒ What the Mars rover has revealed as its next adventure beckons

34 Beyond the airlock:
Ⓒ 60 years of spacewalks
"There's no margin for error..." What it's like to step into space

40 How to see the ISS
Ⓒ Spot the station over your house

60 The fate of the Solar System
Discover our future, from moving moons to chomped-up planets

66 There's something wrong
Ⓒ with the way we use light
Our world is awash with artificial light – but it doesn't have to be

Regulars

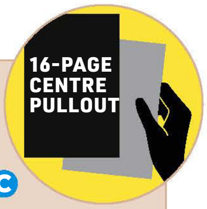
6 Eye on the sky
10 Bulletin
16 Cutting edge
18 Inside *The Sky at Night*
21 Interactive
25 Field of view
26 Subscribe to *BBC Sky at Night Magazine*
72 Explainer: Saturn's vanishing rings Ⓒ
74 Skills for stargazers
98 Q&A: a dark energy sceptic Ⓒ

Astrophotography

76 Capture
78 Processing
80 Gallery

Reviews

86 Canon EOS R8 mirrorless camera body Ⓒ
90 Ikarus Technologies StellarMate Pro 128GB
95 Gear
96 Books



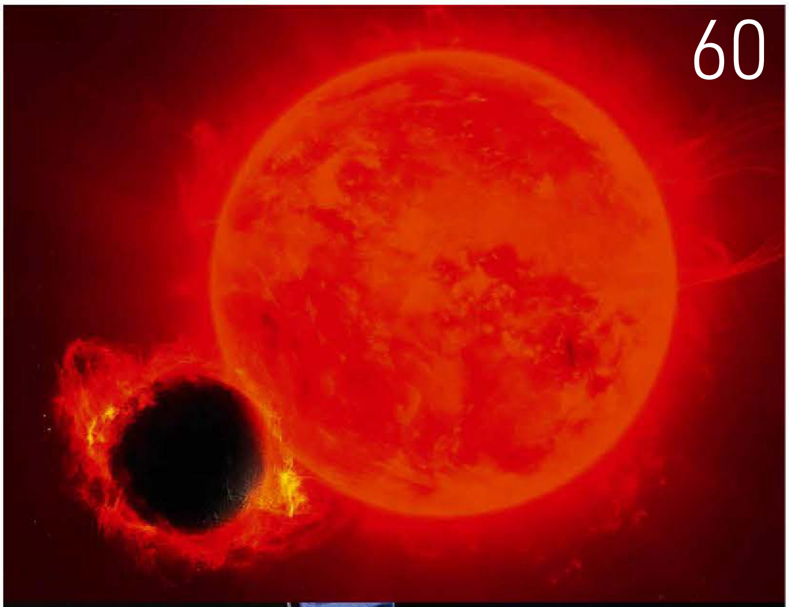
The Sky Guide

44 Highlights
46 The big three Ⓒ
48 The planets
50 March's all-sky chart
52 Moonwatch
53 Comets and asteroids
53 Star of the month
54 Binocular tour
55 The Sky Guide challenge
56 Deep-sky tour
58 March at a glance

COVER IMAGE: MARK GARLICK. THIS PAGE: NASA/JPL-CALTECH/MSSS, STOCKTREK IMAGES/GETTY, BETTMANN/GETTY, NASA/JPL/SPACE SCIENCE INSTITUTE, DSZC/GETTY, @THESHED_PHOTOSTUDIO, NASA/ESA/CSA/STSCI/V. ESTRADA-CARPENTER (SAINT MARY'S UNIVERSITY)

New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**



This month's contributors

Jane Green

Science journalist

"It was fascinating to look at what fate awaits our beloved Solar System as it changes and evolves over the next few decades to billions of years' time." **Jane tells us what lies in store on page 60**

Paul Bogard

Dark-sky advocate

"Once people see the night as part of the landscape they love, they'll start to see – and object to – the overused and misused lights that disrupt it." **Paul considers how to curb our addiction to artificial light, page 66**

Ivana Peranic

Astrophotographer

"The International Space Station streaking across the night sky is a wonderful sight to behold. I took the next step and captured an image for a closer look." **Photograph the ISS with Ivana on page 74**

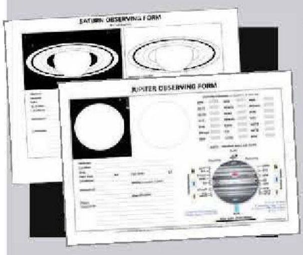
FREE BONUS CONTENT

Find it at **www.skyatnightmagazine.com/bonus-content**

MARCH HIGHLIGHTS

Bending light to discover distant stars

Mathilde Jauzac on how JWST used a light-bending gravity trick to find hidden stars in the 'cosmic noon'.



Download and print observing forms

Keep track of your observations of the Sun and the planets through the eyepiece with our printable forms.

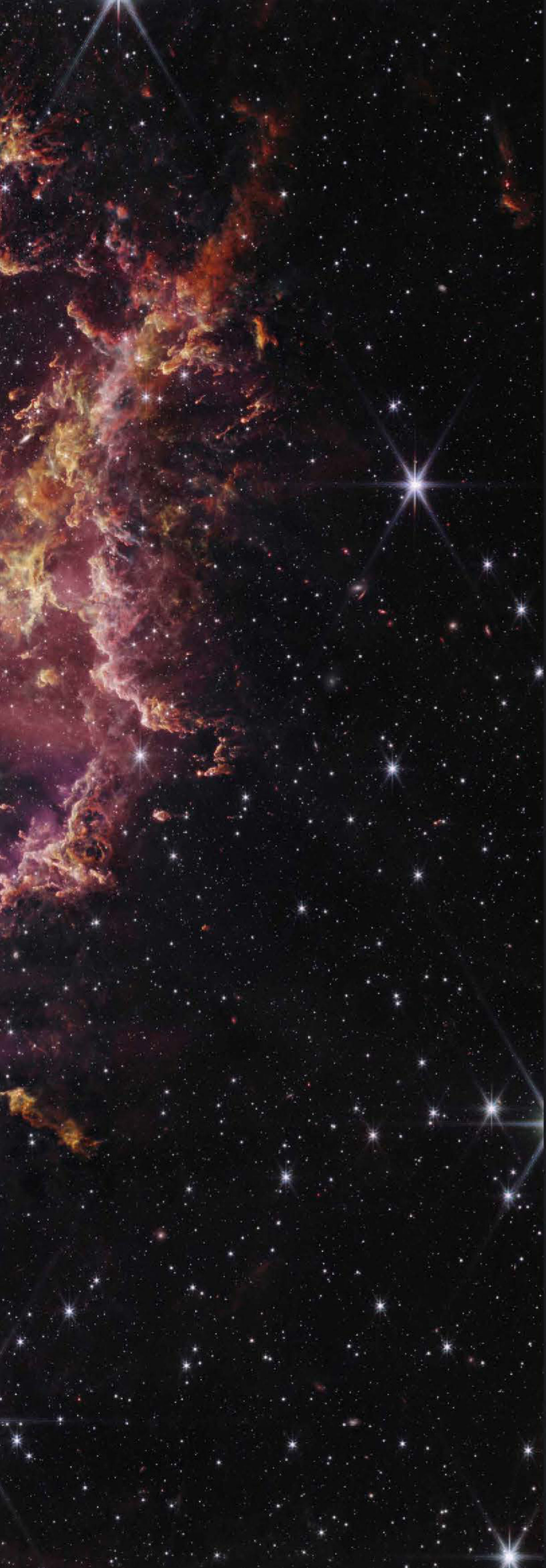
Extended astro image galleries

The best images of the cosmos by professional telescopes, spacecraft and *BBC Sky at Night Magazine* readers.

The Virtual Planetarium

Beta Eridani
Beta Orionis
IC 2118

Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.



COSMIC CRADLE

JWST explores NGC 346, a colossal star-forming cluster that's shedding new light on a planet-making mystery

JAMES WEBB SPACE TELESCOPE, 16 DECEMBER 2024

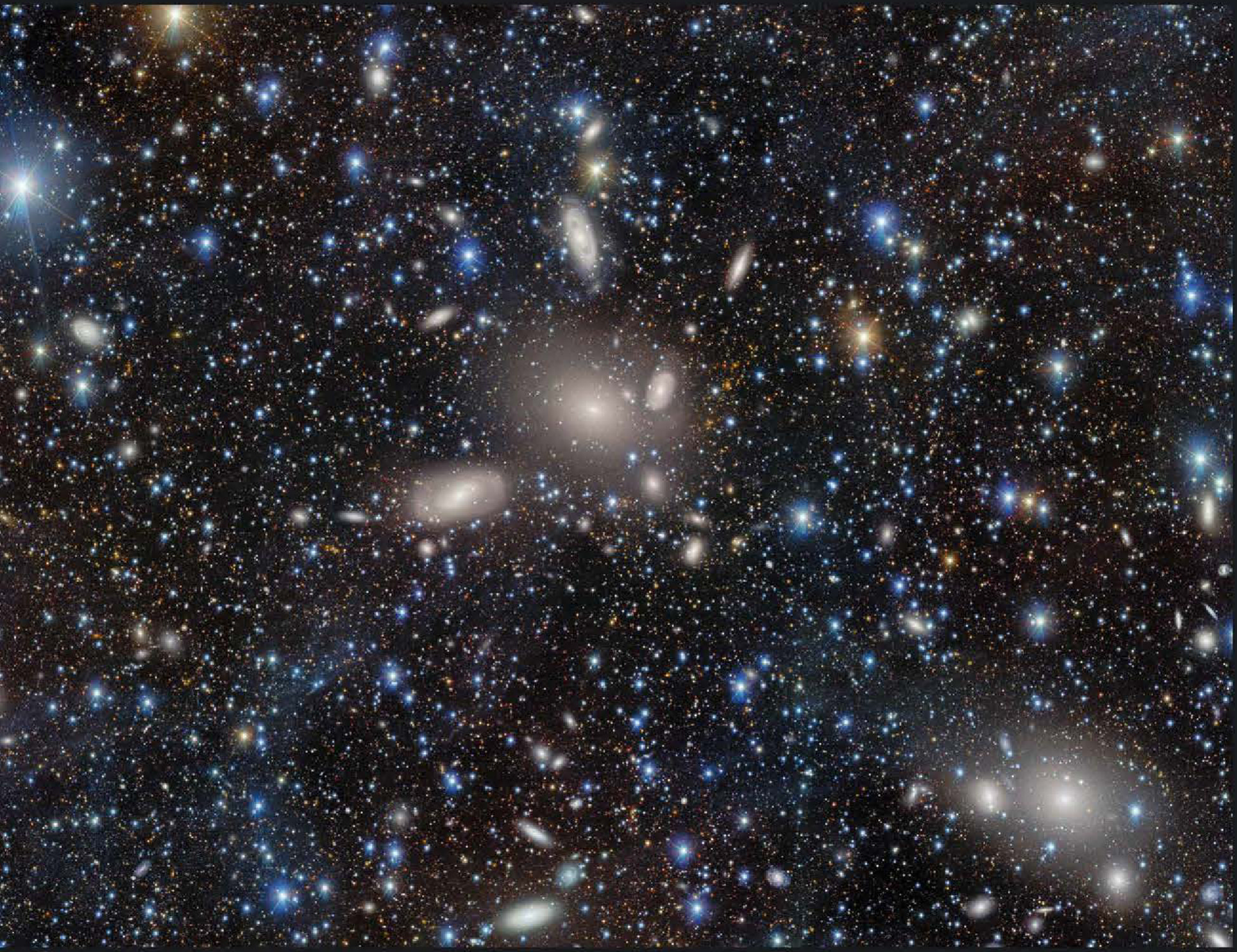
How soon after the Big Bang did the first planets begin forming around stars?

For some time, helium- and hydrogen-rich stars in the early Universe were thought unlikely to host planets, because the protoplanetary discs around them contain very low levels of heavier elements such as iron and carbon, and dispersed within just two or three million years. So Hubble's 2003 discovery of a massive planet orbiting a very ancient star had astronomers puzzled.

Now, JWST has given astronomers new insight into this mystery. It turned to NGC 346, an enormous star-forming region stretching 200 lightyears across. Its survey of NGC 346, which is also very low in heavy elements, revealed discs around stars up to 30 million years old. This suggests that discs around early stars lasted longer, giving their scant supply of heavier elements time to form planets.

NASA/ESA/CSA/STScI/OLIVIA C. JONES (UK ATC) GUIDO DE MARCHI (ESTEC) MARGARET MEIXNER (USRA)

FREE BONUS CONTENT
Explore a gallery of these and more stunning space images
www.skyatnightmagazine.com/bonus-content



◁ Abell bodies

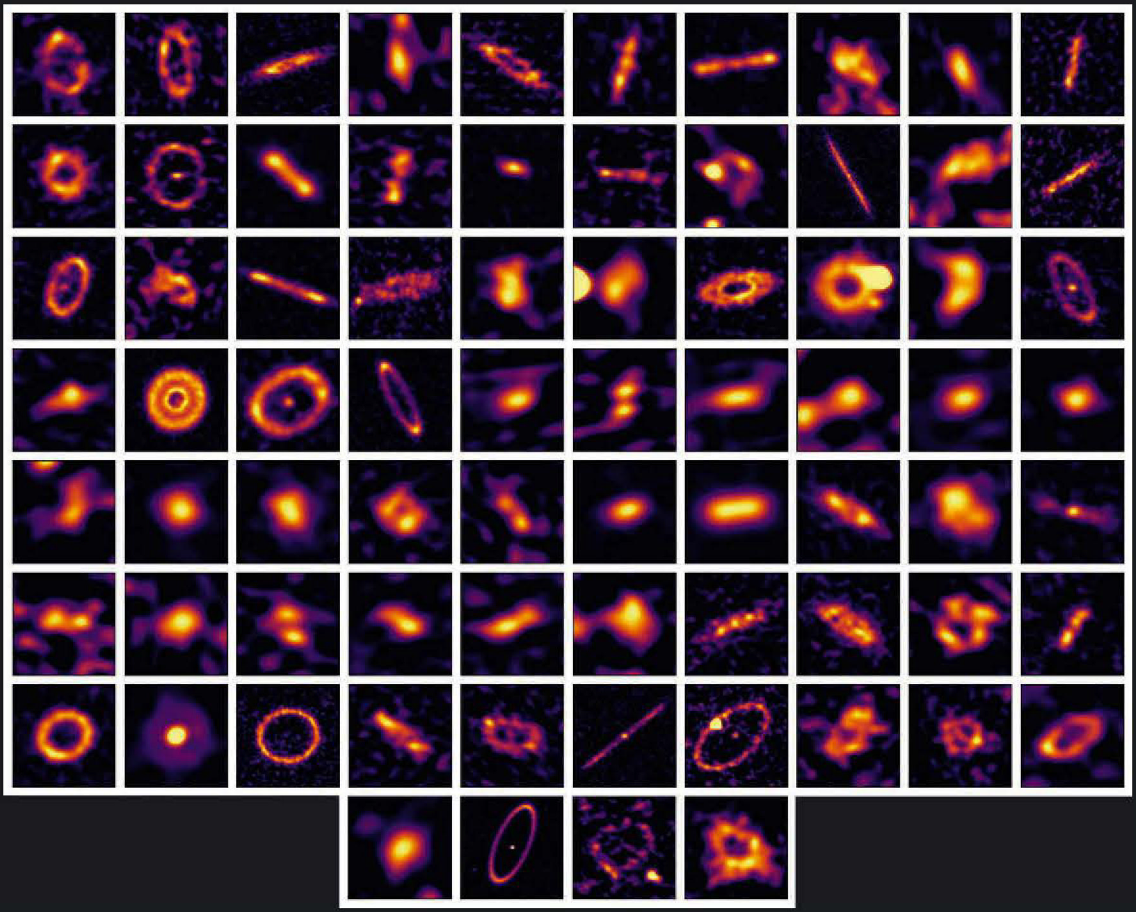
VICTOR M BLANCO 4-METER TELESCOPE, 1 JANUARY 2025

Abell S636, aka the Antlia Cluster, is a cluster of over 230 galaxies bound by gravity in the constellation of Antlia. Two large ellipticals – NGC 3268 and NCG 3258 – dominate the picture, but the cluster is also home to a wide range of irregular, lenticular and ultra-compact dwarf galaxies.

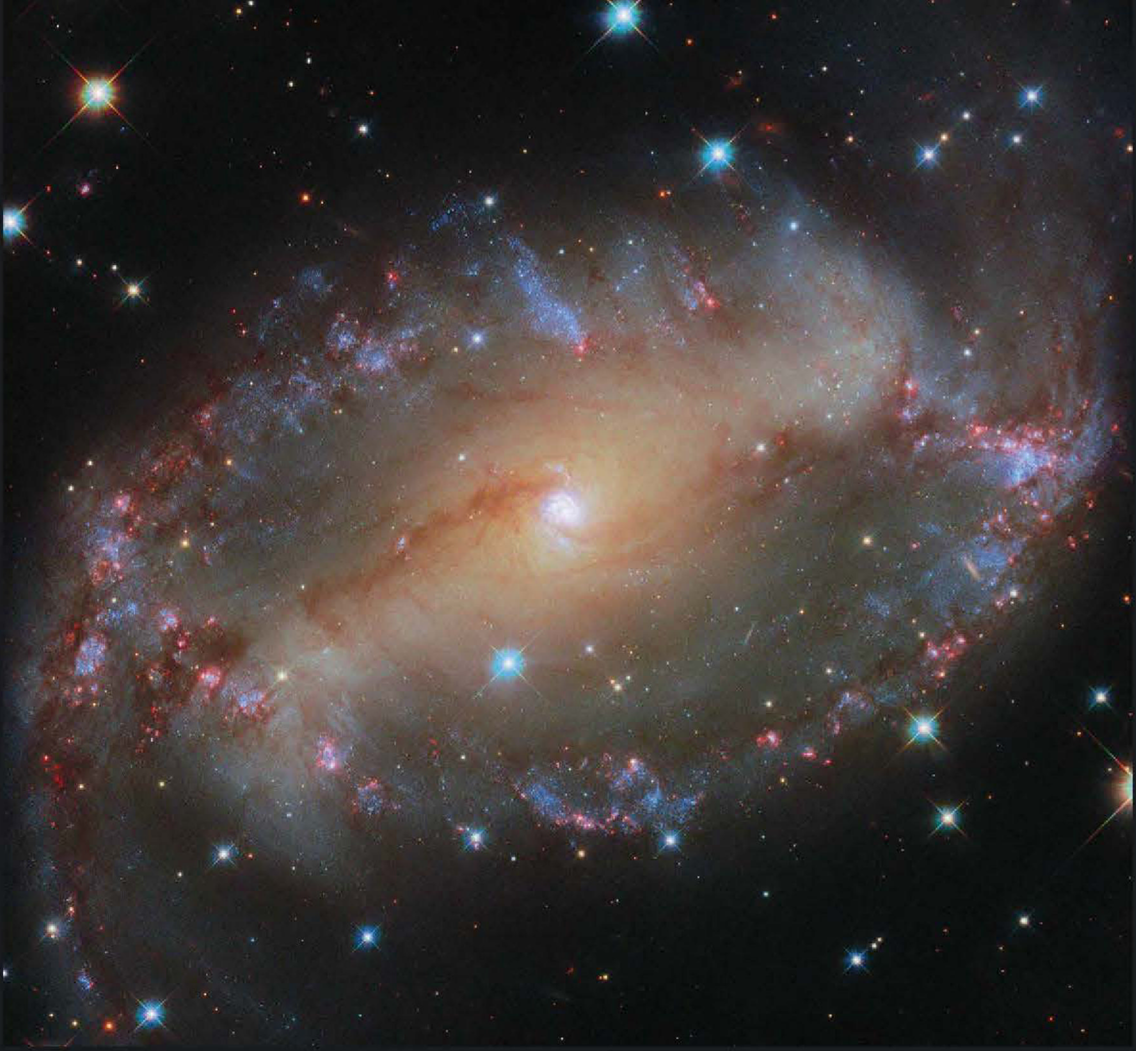
Belt up! ▷

ATACAMA LARGE MILLIMETER/ SUBMILLIMETER ARRAY, 17 JANUARY 2025

Solar System comets originate in the Kuiper Belt or the Oort cloud, but other planetary systems have belts of dust and gas around them too. Now ESO's ALMA telescope has imaged 74 such 'exocomet belts', the pictures revealing that they come in all shapes and sizes.



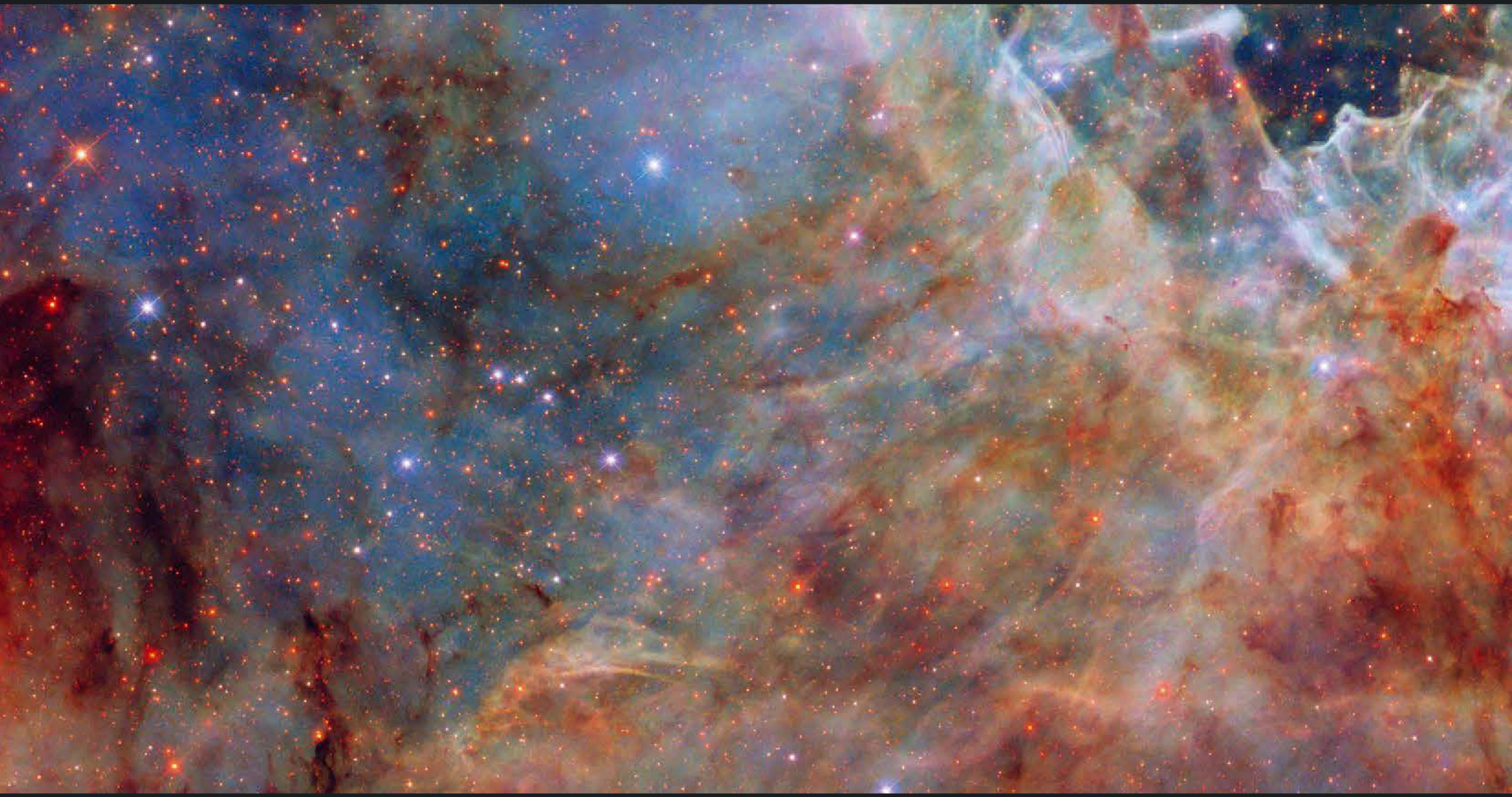
DARK ENERGY SURVEY/DOE/FNAL/DECAM/CTIO/NOIRLAB/NSF/AURA/IMAGE PROCESSING: R. COLOMBARI & M. ZAMANI (NSF NOIRLAB), ALMA (ESO/NAOJ/NRAO)/SMA/L. MATRÀ ET AL, ESA/HUBBLE & NASA/D. THILKER, ESA/HUBBLE & NASA/C. MURRAY



◁ Herschel's thumbprint?

HUBBLE SPACE TELESCOPE, 16 DECEMBER 2024

NGC 2566 is a barred spiral galaxy lying 76 million lightyears from Earth in the constellation of Puppis. The Hubble researchers that captured this picture describe it as resembling an eye. To us, it looks more like a thumbprint on the sky – perhaps that of William Herschel, who discovered the galaxy in 1785.



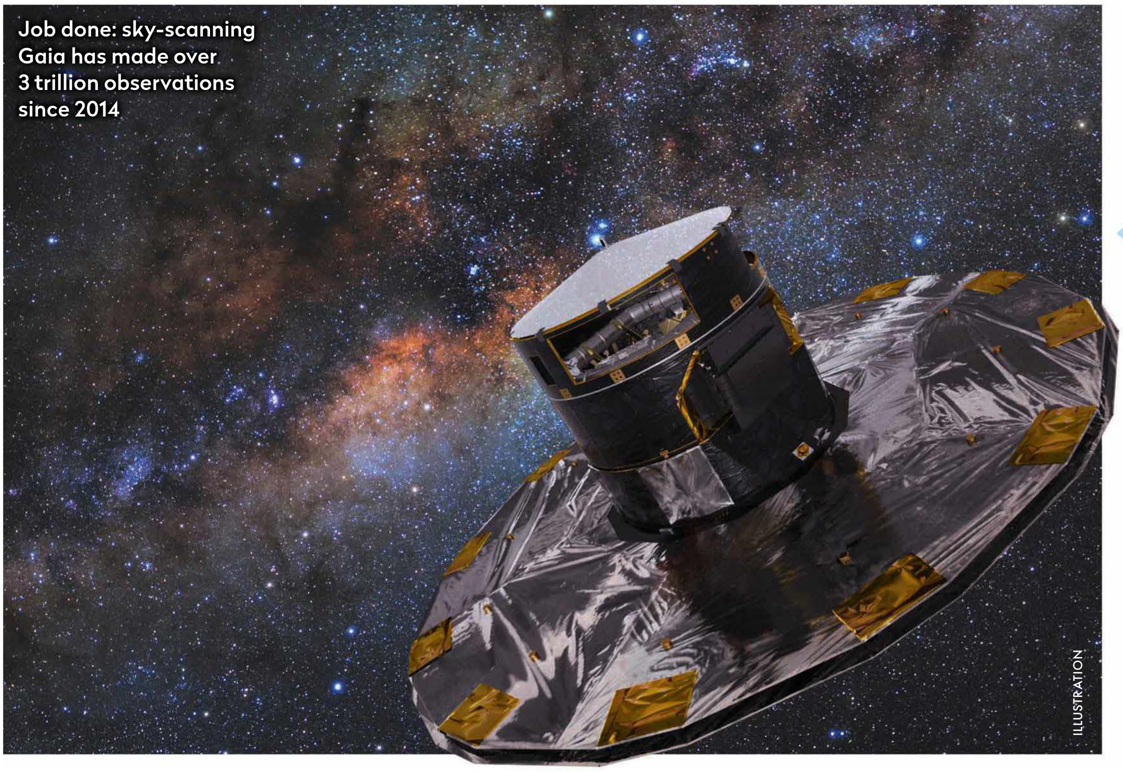
△ Spider's web

HUBBLE SPACE TELESCOPE, 20 JANUARY 2025

This Hubble image shows a small part of the Tarantula Nebula, which lies in the Large Magellanic Cloud and is one of the most prolific star-forming regions in the nearby Universe. While the core of the Tarantula holds some of the most massive stars we know of, about 200 times the mass of the Sun, this image captures the serenely sparkling scene at the nebula's outskirts.

The latest astronomy and space news, written by Ezzy Pearson

BULLETIN



Job done: sky-scanning Gaia has made over 3 trillion observations since 2014

Gaia satellite sees its last stars

ESA's craft made the first 3D map of our Galaxy and tracked billions of stars

After spending over a decade mapping our Milky Way, the European Space Agency's Gaia satellite is now being put into retirement. The spacecraft has almost depleted its reserves of the cold nitrogen gas it uses to stay locked on target and will now be moved to a graveyard orbit.

Launched on 19 December 2013, Gaia has spent the last 11 years tracking the position, motion, brightness and other characteristics of over two billion stars. It has amassed some 142TB of data, creating the most detailed 3D models of our Galaxy ever made.

"Gaia has changed our impression of the Milky Way. Even basic ideas have been revised, such as the rotation of our Galaxy's central bar, the warp of the disc, the detailed structure of spiral arms, and interstellar dust near the Sun," says Stefan Payne-Wardenaar, scientific visualiser for the Haus der Astronomie, Germany.

"Still, the distant parts of the Milky Way remain educated guesses based on incomplete data. With further Gaia data releases, our view of the Milky Way will become even more accurate."

Over the next few weeks, the spacecraft will undertake several technology tests, revealing how the instruments have held up after a decade in space, allowing the data team to better calibrate its past measurements. Gaia was repositioned for these tests, temporarily increasing its magnitude, making the spacecraft bright enough to be seen in small amateur telescopes.

Eventually, Gaia will be moved out of its current position at Lagrange Point 2 – a gravitationally stable area of space 1.5 million km (900,000 miles) from the Sun – to prevent that orbit from becoming cluttered, before the craft is shut down on 27 March 2025.

This won't be the end for Gaia's data, however. ESA is planning to release a new data set in 2026, covering the first 5.5 years of its observations – the originally planned duration of the Gaia mission. The team hopes to make the full 11 years of data public by the end of the decade, meaning Gaia will still be revolutionising our view of the Galaxy for years to come. **www.esa.int**

Comment

by Chris Lintott

One of my favourite episodes of *The Sky at Night* covered 2018's second Gaia data release. We gave astronomers a few weeks to get to grips with the data, then stuck a camera in their faces and asked what they'd found.

Each exploded with enthusiasm; they told us about hints of the Milky Way's violent past, the stars that bounced through the Galaxy's disc and the remnants of a dwarf system which somehow acquired the most ridiculous name in all of astrophysics: the Gaia-Enceledus sausage.

Everyone said the same: that this was just the start; that the final data set would truly blow our minds. Gaia has given us the best map of the cosmos we've ever had. I can't wait to see its finished form.

Chris Lintott co-presents *The Sky at Night*

GAIA: ESA/ATG MEDIALAB/BACKGROUND: ESO/S. BRUNIER, ANDREAS PACK, COURTESY FACULTY OF SCIENCE RESEARCH TEAM

15016,0
60015,1
70017,8
61016,7

The study examined lunar rock samples gathered by Apollo astronauts

Moon study sheds light on Earth's water

Researchers pinpoint which meteorites delivered our oceans

Our Moon could be a chip off the old block, according to a new study which shows it is mostly made of material that originated on the early Earth. As well as untangling how our lunar companion formed, researchers also found evidence of how water came to our planet.

The prevailing theory is that our Moon was created when a Mars-sized protoplanet, named Theia, collided with the early Earth. The Moon then coalesced out of the combined debris. The study looked at 14 lunar rock samples, comparing them to similar minerals found on Earth by measuring levels of oxygen-17, a rare isotope of oxygen. Both lunar and terrestrial samples had very similar levels, suggesting they shared a common source. This would mean that most of the material which formed the Moon was thrown off the early Earth during this impact, with little contribution from protoplanet Theia.

"One explanation is that Theia lost its rocky mantle in earlier collisions and then slammed into the early Earth like a metallic cannonball," says Andreas Pack from Göttingen University, who took part in the study. "If this were the case, Theia would be part of Earth's core today, and the Moon would have formed from ejected material from Earth's mantle. This would explain the similarity in the composition between the Earth and the Moon."

The measurements have also narrowed down another of our planet's great mysteries: where did its water come from? Our current best theory here is what's known as the 'late veneer event' – water was brought to the surface by asteroid impacts after the Moon was created. The similar levels of oxygen-17 found in the study allowed scientists to home in on the type of meteorite that brought water to Earth, a class called enstatite chondrites, since their composition matches the study's findings most closely.

www.uni-goettingen.de

Patches in the Northern Lights explained

Improved camera tech reveals strange new structures in the aurora

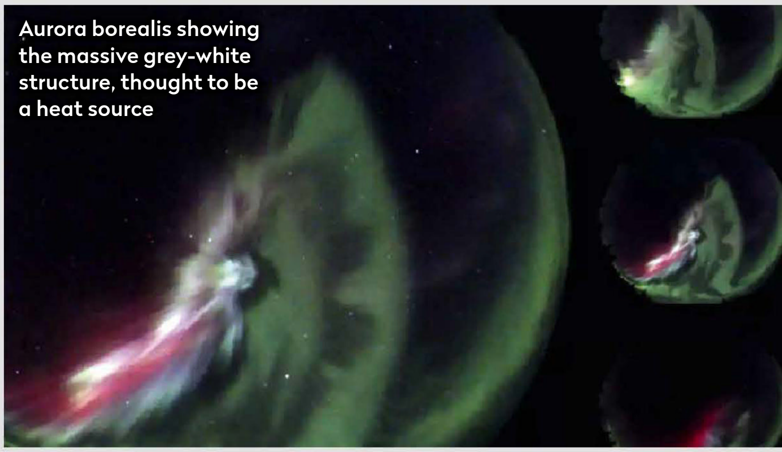
The aurora is renowned as an explosion of colour, but it's the appearance of strange white-grey patches in it that is currently drawing the attention of astronomers.

Commenting on the new study she led, Emma Spanswick from the University of Calgary says, "You'd see this dynamic green aurora, some of the red aurora in the background and, all of a sudden, you'd see this structured grey-toned or white-toned emission – almost like a patch – connected to the aurora."

The grey structures, known as structured continuum emissions, stretch anywhere between tens to hundreds of kilometres across the sky.

The study found the grey patches show spectral similarities to traditional aurorae – where particles from the Sun interact with atoms in the atmosphere to make them glow – but also have signs that they were created by heating within the upper layer of the atmosphere, the ionosphere.

Interest in the grey patches has grown lately, in part due to another recently discovered phenomenon known as STEVE (Strong Thermal Emission Velocity Enhancement), a purple band sometimes seen alongside the aurora. While the spectra of the two appear similar, the grey patches are much more embedded within active aurorae.

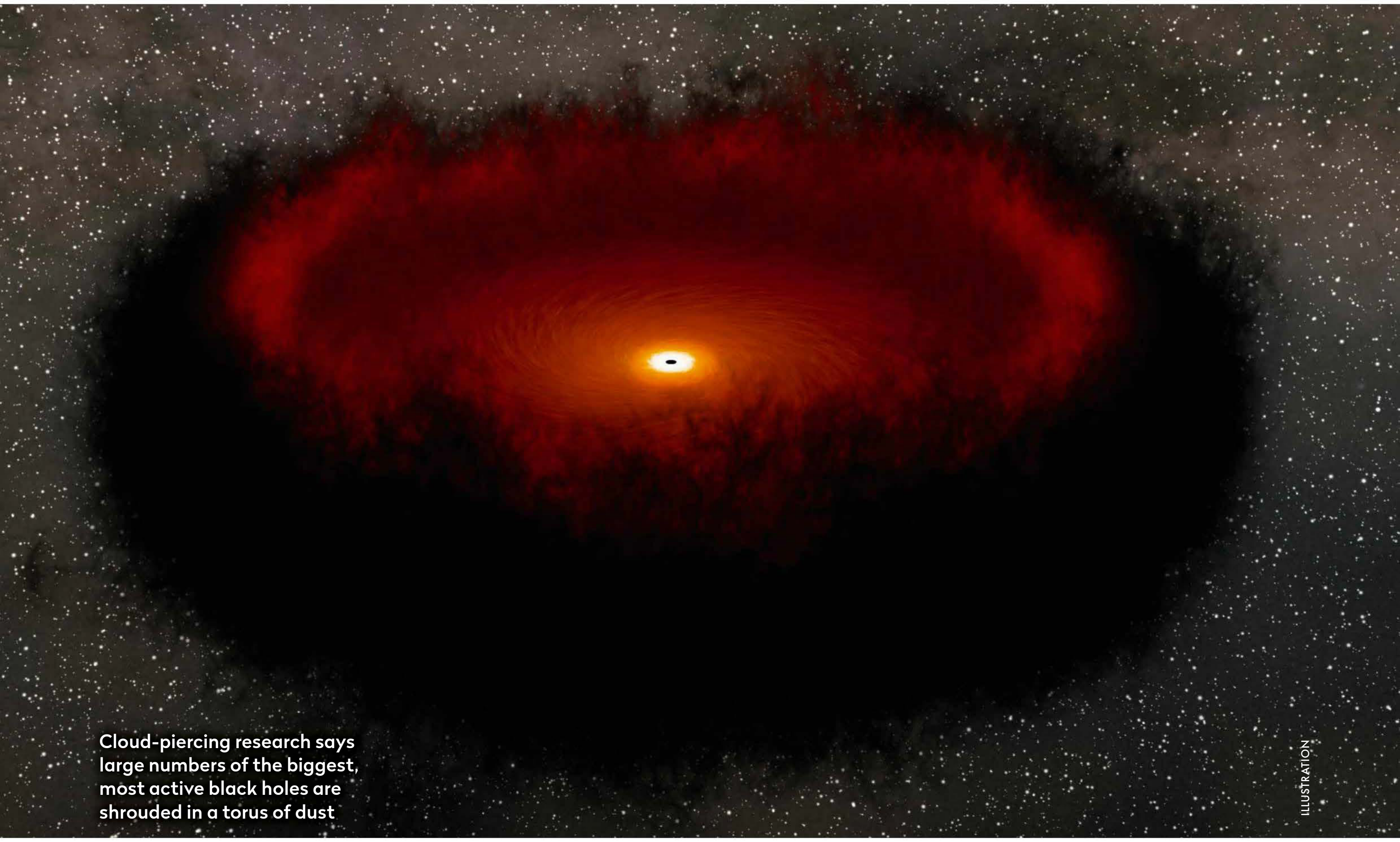


Aurora borealis showing the massive grey-white structure, thought to be a heat source

"It's harder to pick out if you were to look at it, whereas STEVE is separate from the aurora – a big band crossing the sky," says Spanswick.

The investigation of both phenomena has become possible due to the rise of advanced camera technology, which allows the aurora's true colours to appear in images when they aren't always obvious in the sky.

www.ucalgary.ca



Cloud-piercing research says large numbers of the biggest, most active black holes are shrouded in a torus of dust

Many of Universe's black holes are hiding

Study says at least a third of all giant black holes may be obscured by rings of dust

Black holes are, by their very nature, difficult to see. Some, cloaked in clouds of dust, are even harder to find. But now a new study could have pinned down exactly how many black holes lie hidden from our view.

Most large galaxies are thought to house a supermassive black hole with the mass of a billion Suns. This powerful gravity allows them to capture gas and dust, shrouding themselves with it. Close to the black hole, friction superheats this gas, causing it to glow incredibly brightly, while a cooler doughnut or torus surrounds it. When face-on to Earth, the bright central region is clear through the doughnut's hole, but when observed edge-on the dusty torus blocks the view.

Fortunately for astronomers, absorbing this light heats the torus, causing it to glow in the infrared, meaning edge- and face-on black holes are equally bright in these wavelengths.

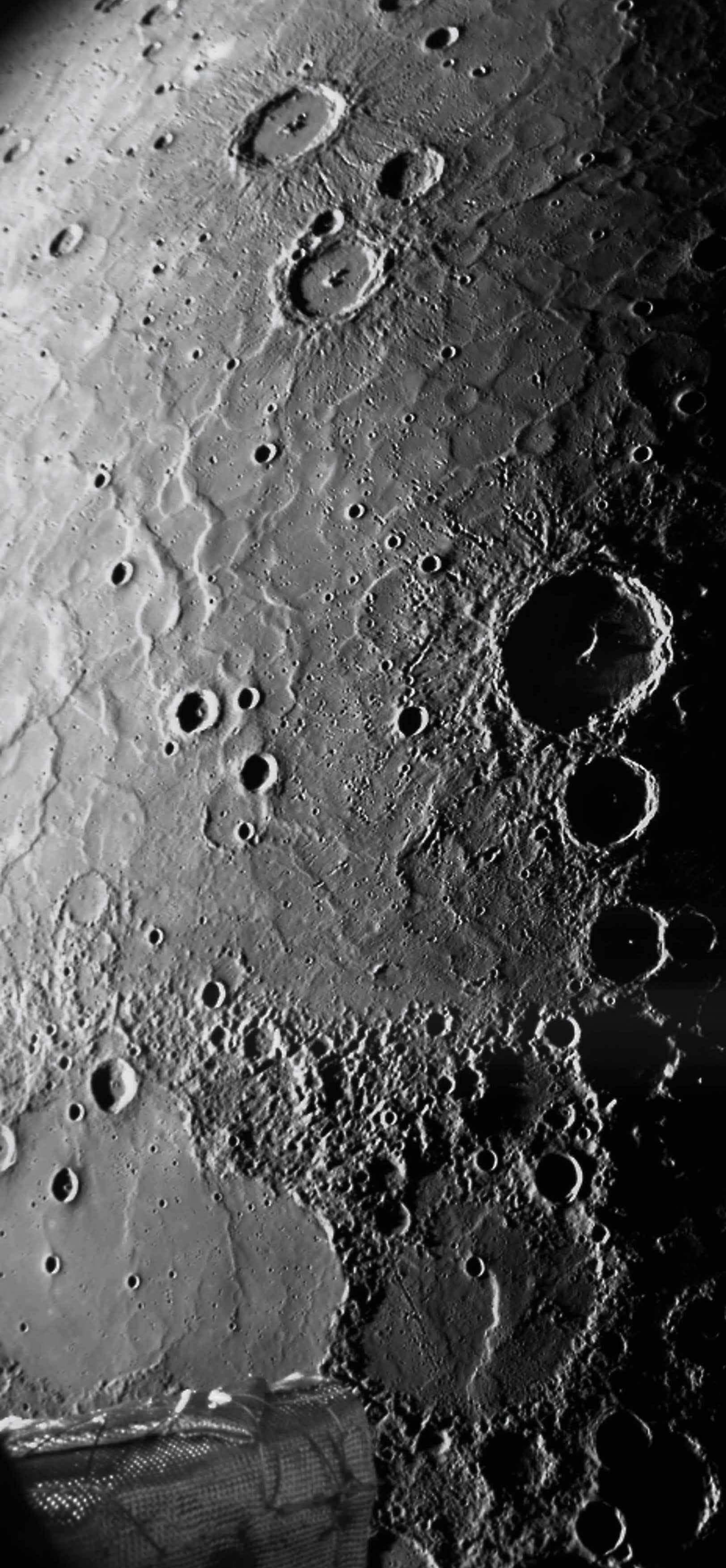
A team of researchers examined data taken by NASA's Infrared Astronomical Satellite (IRAS) in 1983 and identified hundreds of potential black holes. These were then observed with the NuSTAR X-ray space observatory, looking for radiation generated by the hottest gas near the black hole.

While X-rays of a lower energy are absorbed by the torus, more energetic X-rays can pierce the clouds, allowing the team to differentiate between face-on and edge-on black holes.

"It amazes me how useful IRAS and NuSTAR were for this project, especially despite IRAS being operational over 40 years ago," says study lead Peter Boorman, an astrophysicist at Caltech in Pasadena, California.

The study found that around 35 per cent of black holes are heavily obscured, a marked increase from previous measurements which found just 15 per cent were hidden. The ratio of hidden to unobscured black holes helps astronomers understand how black holes might have formed. The current theory is they grow by consuming material surrounding them and, as such, you would expect a significant number to be obscured by a torus. It's estimated that around half of all supermassive black holes should be hidden. While this is greater than the value measured, it's close enough that no one's returning to the drawing board to rewrite their theories just yet.
www.jpl.nasa.gov

NASA/JPL-CALTECH, ESA/BEPICOLOMBO/MTM X 2



BepiColombo snaps Mercury fly-by close-up

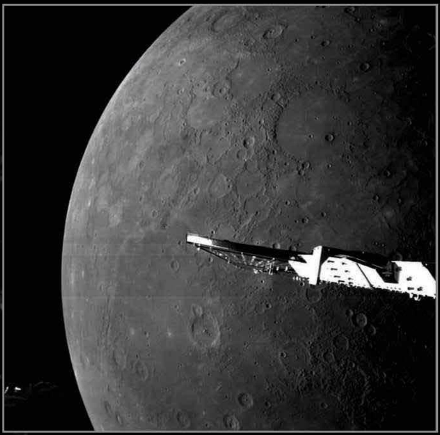
The spacecraft is on track to enter orbit around the planet

ESA's BepiColombo probe whipped past Mercury for the sixth time on 8 January, passing just 295km (183 miles) over the planet's northern pole. The fly-by was the mission's final gravity-assist manoeuvre, which will place the spacecraft into orbit around Mercury in 2026.

The spacecraft snapped several images during the fly-by, including one of the planet's terminator, the line between the light and dark side. The low angle of the Sun at the pole highlights several of the craters, but it also means the dark shadowy corners of these craters never see sunlight. These are some of the coldest places in the Solar System, despite being located on the closest planet to the Sun.

When BepiColombo enters Mercury orbit, it will separate into two orbiters, the Mercury Planetary Orbiter and the Mercury Magnetospheric Orbiter, before starting its science mission in 2027.

"BepiColombo's main mission phase may only start two years from now, but all six of its fly-bys of Mercury have given us invaluable new information about the little-explored planet," says Geraint Jones, BepiColombo's project scientist at the European Space Agency.



BepiColombo took a selfie as it passed above the permanently dark craters at Mercury's north pole

Bumper time for private spaceflight

A slew of lunar landers and new rockets set out for the stars, with mixed results

It's been an exciting time for spaceflight, as 2025 kicked off with three major private launches in just two days.

On 15 January, SpaceX launched two lunar landers. One is the Resilience lander from Japanese company ispace, the company's second shot at the Moon after their Hakuto lander crashed into the surface in February 2023. With it is the mini rover Tenacious, which will be the first-ever private planetary rover – if they stick the landing in May.

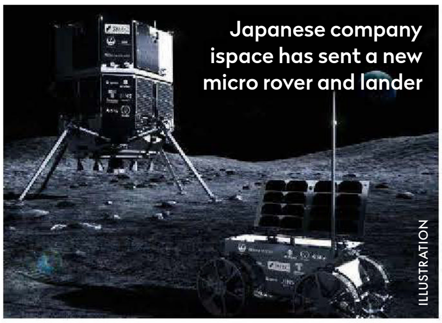
Also launched in the same Falcon 9 rocket was Blue Ghost, from US company Firefly Aerospace, carrying 10 NASA experiments as part of the Commercial Lunar Payload Services programme. These include a new soil-sampling device, navigation systems, radiation-tolerant computing and even a lunar dust shield, all of which will be tested if it manages to set down on the lunar surface on 2 March.

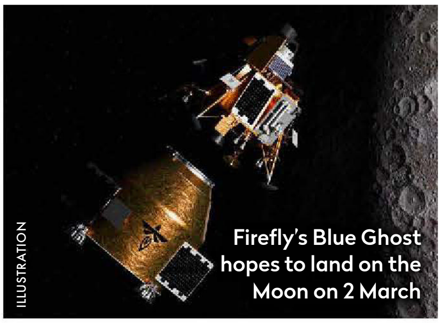
The next day, on 16 January, Blue Origin, founded by Amazon's Jeff Bezos, flew the first test of its New Glenn rocket. While its second stage successfully separated and reached mid-Earth orbit, the booster stage failed to land on a waiting barge as telemetry blacked out shortly after separation.

New Glenn is designed to be a heavy launch vehicle, capable of lifting 45,000kg (50 tonnes) into low-Earth orbit. What really sets it apart, however, is its 7-metre-wide (23ft) payload faring, meaning it can carry spacecraft much larger than those that can be carried by rival SpaceX's Falcon series.

A few hours later, SpaceX launched the seventh test flight of its Starship vehicle, which ended in an unexpectedly spectacular fashion (see opposite).

Jeff Bezos's New Glenn launched from Cape Canaveral on 16 January


Japanese company ispace has sent a new micro rover and lander



Firefly's Blue Ghost hopes to land on the Moon on 2 March

Pluto and its moon formed with a gentle kiss

Investigators say encounter may have melted dwarf planet's frozen heart

Pluto and its moon Charon may have united through a kiss rather than a collision, according to a recent study. The research could give insight into how the dwarf planet is able to support a subsurface ocean.

No one is sure exactly how Pluto and Charon first came together. Previous theories held that they formed from the debris of a large impact, in a similar way to how our own Moon is believed to have formed (see page 11).

"Pluto and Charon are different – they're smaller, colder and made primarily of rock and ice. When we accounted for the strength of these materials, we discovered something completely unexpected," says Adeene Denton from the University of Arizona, who led the study. "Most planetary collision scenarios are classified as 'hit and run' or 'graze and merge'. What we've discovered is something entirely different – a 'kiss and capture' scenario where the bodies collide, stick together briefly and then separate while remaining gravitationally bound."

Charon (left) and Pluto (right) were briefly stuck together

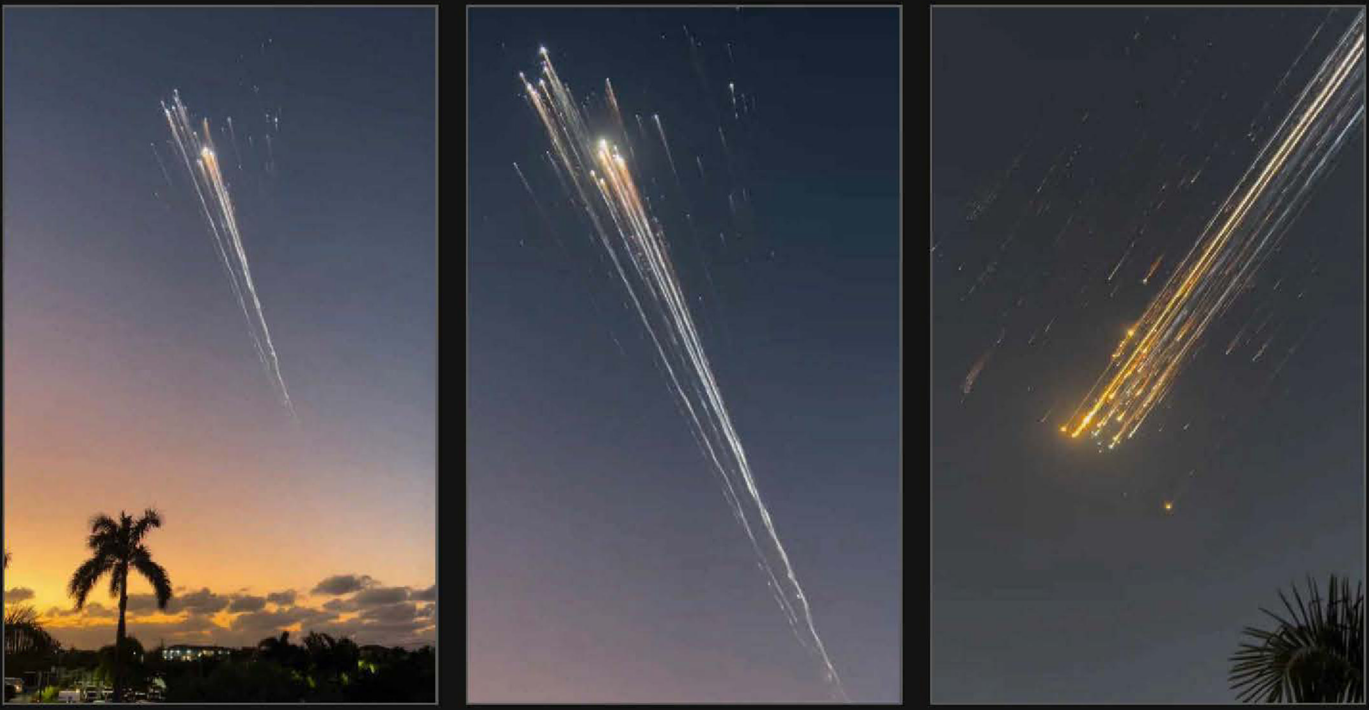
When the giant snowman-like structure eventually broke apart, Charon remained mostly intact.

The idea also explains another of Pluto's great mysteries. When the New Horizons mission flew past the diminutive world in 2015, it saw signs of a liquid water ocean. Geologists have struggled to explain how Pluto's interior could be warm enough for such a layer. The tidal forces from the gravitational tug of war during the kiss-and-capture event, however, would have created internal heat that could have melted the dwarf planet's frozen heart.

www.news.arizona.edu

MIGUEL J. RODRIGUEZ CARRILLO/STRINGER/GETTY, ISPACE, FIREFLY SPACE, SWRI/ JHUAPL/NASA, SPACEX X 2, MARCUS HAWORTH X 3

▲ The 16 January launch was the seventh Starship test flight and the first for a slightly taller Block 2 version of the upper stage



▲ The skies above Turks and Caicos were streaked with the remains of the upper stage after it exploded, likely due to a fuel leak

Starship explosion rains down debris

SpaceX's seventh test launch ends in an eye-catching failure

A shower of sparkling fragments rained down from the sky after SpaceX's seventh test launch of its new Starship vehicle ended in a spectacular explosion.

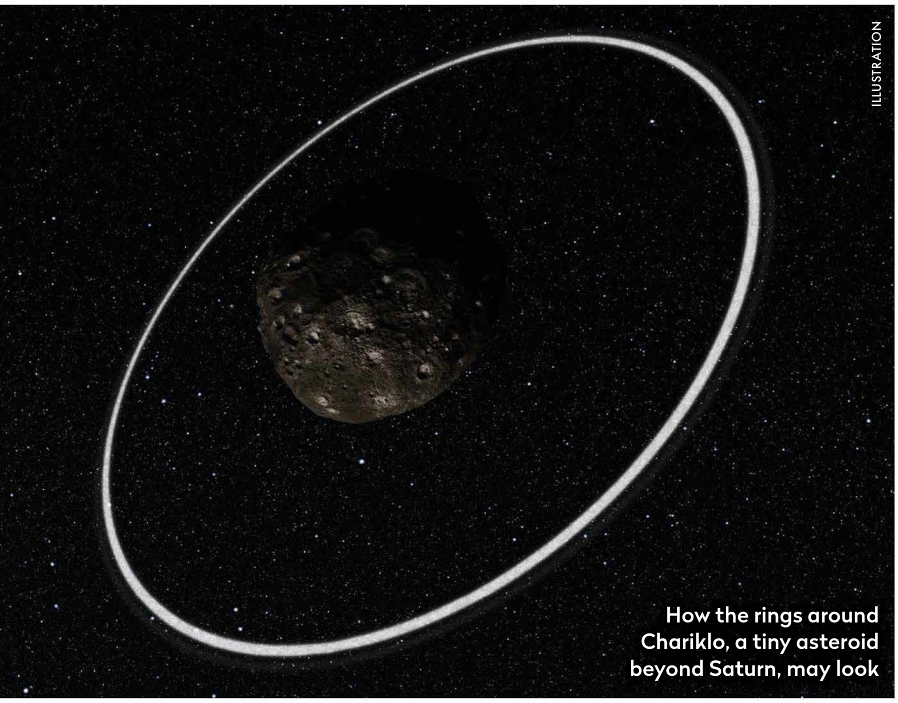
The largest and most powerful spacecraft ever lifted off from SpaceX's Starbase launch site in Texas on 16 January at 10:37pm GMT (4:37pm CST). Things seemed to be proceeding as planned, with Starship separating from its Super Heavy booster a few minutes into the flight. However, around eight minutes into the mission, the Starship upper stage stopped transmitting and the engines shut down soon after. Three minutes later, inhabitants of the Turks and Caicos Islands witnessed a fireworks display as the craft exploded overhead.

Though there were no casualties, debris rained down on the islands and a flight diversion was put in place. The Federal Aviation Administration is now requiring SpaceX to fully investigate what went wrong. It's thought an oxygen leak caused a fire, which led to the 'unscheduled rapid disassembly'.

The booster stage, however, was much more successful. It returned to Starbase, where it was caught by a pair of 'chopstick' mechanical arms – the second time the company has pulled off the manoeuvre.
www.spacex.com

Our experts examine the hottest new research

CUTTING EDGE



How the rings around Chariklo, a tiny asteroid beyond Saturn, may look

Rings are not a rarity

Worlds with rings are spread across the outskirts of our Solar System

While Saturn is the uncontested Lord of the Rings, it is by no means the only body in the Solar System to host a ring system. The flickering effect of stellar occultation – when a planet passes in front of a background star, briefly blocking it – revealed the presence of rings around Uranus in 1977 and Neptune in 1984. A set of tenuous rings were discovered around Jupiter too, during the Voyager 1 fly-by in 1979.

But only in the last decade or so has it been realised that rings also exist around bodies other than the gas giant planets. In fact, as Bruno Sicardy, at the Observatoire de Paris, France, and his colleagues point out in a new research paper, a total of seven objects in the Solar System are now known to have rings.

These newly discovered ring systems exist around small, icy bodies in the outer Solar System, and include Chariklo, a centaur object orbiting between Saturn and Uranus, and the large dwarf planet Haumea, beyond Neptune. Two rings have been spotted around Quaoar, another large trans-Neptunian object. Chiron, located between Saturn and Uranus, is now known to be surrounded by a diffuse halo of particles that also contains more dense structures, which may indicate a ring system currently in formation.

There's a great deal of diversity in terms of the sizes (relative to their host body) and structures of these ring systems, and they almost certainly originated through different processes. The rings around Chariklo, for example, probably formed from material ejected from its surface by cometary outbursts during its elliptical orbit. Haumea is itself a very curious object – it rotates extremely rapidly (taking just four hours) and has been stretched into an elongated ellipsoid shape. This is thought to be due to a giant collision that knocked Haumea into a frenzied spin and smashed off the material that formed its two moons and rings.

Impossible rings

Quaoar's two rings are by far the more puzzling. In contrast to all other rings in the Solar System, Quaoar's sit well beyond the Roche limit of their parent body. This means that tidal effects from orbiting the dwarf planet are too weak to break apart larger bodies and the dusty particles should have clumped together into a set of moons. The discovery of Quaoar's two rings in 2021 and 2023, therefore, runs contrary to all expectations of how rings can remain stable. One possible reason for their existence, the authors explain, is that in the super-cold temperatures of trans-Neptunian objects, ice particles tend to bounce off each other rather than accreting.

"There's a great deal of diversity in these ring systems and they almost certainly originated through different processes"

The researchers end the paper with an intriguing prediction. Triton, the largest moon of Neptune, is in a slowly decaying orbit, as tidal effects sap its energy. In about 1.4 billion years, it's predicted that orbital decay will cause it to dip within the Roche limit of the planet, when it may be ripped apart rather than plunging into the planet's atmosphere. If this does happen, the researchers note that Neptune, not Saturn, would then sport the most spectacular rings in the Solar System.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading… *Origins of Rings in the Solar System* by Bruno Sicardy et al. **Read it online at: arxiv.org/abs/2412.00853**

ESO/L. CALÇADA/M. KORNMESSER/NICK RISINGER (SKYSURVEY.ORG), NASA'S GODDARD SPACE FLIGHT CENTER JHUAPL/SWRI

Ultraviolet Universe gets a new horizon

NASA's New Horizons spacecraft reveals a hidden side to the cosmos

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

As part of the publicity for the fly-by of Pluto by the New Horizons probe back in 2015, a NASA app encouraged everyone to go outside and enjoy 'Pluto time' – the period after sunset or before dawn when the sky is as bright as it is at midday on the surface of the Kuiper Belt's most famous denizen.

It was a good way of viscerally understanding quite how far from the warm inner Solar System the plucky little spacecraft had travelled. New Horizons is now nearly twice as far away as it was then and taking advantage of its isolated position to stare out at the Universe. Recent observations made by the spacecraft's team, and reported in the research paper I've been reading this month, study the background light which dimly illuminates its journey into interstellar space.

Paying attention to such background light has a long tradition in astronomy. The cosmic microwave background provides the best evidence for our Universe's beginnings in a hot Big Bang, and studies of the X-ray background indicated the presence of exotic objects such as growing black holes long before individual sources were identified. In the ultraviolet, measuring the brightness of the background can help us check whether our ideas about when and where stars form in the cosmos, as well as the structure of the Milky Way, are right.

Beyond the Sun

New Horizons has now flown clear of the bright glow of sunlight that fills the inner Solar System. When it was 57 AU from the Sun (where 1 AU is the distance between Earth and the Sun), mission operators decided they were in the perfect place to measure the brightness of the far ultraviolet background for the first time, working at wavelengths its Alice spectrometer can see.

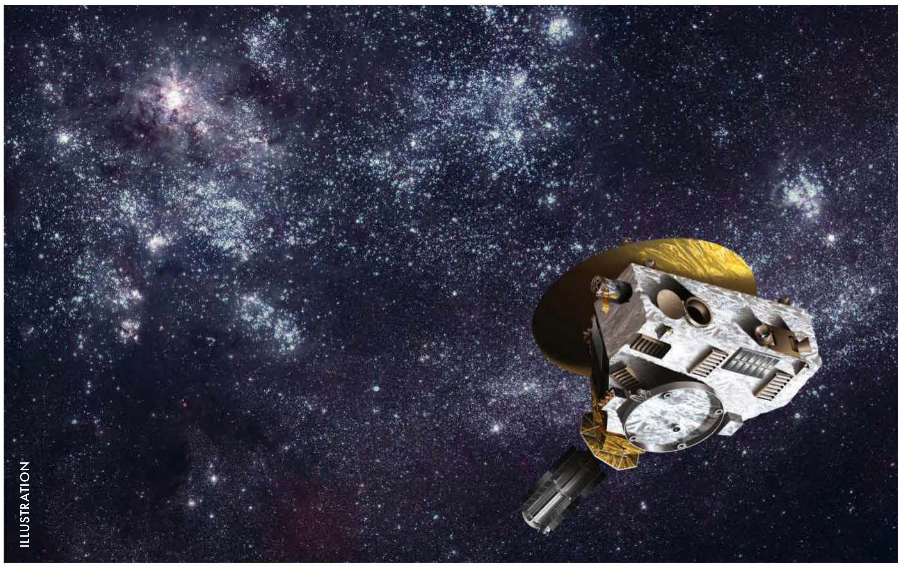
This wavelength range is interesting because only the brightest, most massive stars – typically O and B supergiants – can contribute significantly. But to record their light, the team had to first decide in which direction to look. New Horizons' trajectory was set a long time ago by the manoeuvres that took it past Pluto and, later, tiny Arrokoth, so only the part of the sky that lay in the spacecraft's shadow, away from the Sun, was available. It seemed like a good idea to avoid the Milky Way's disc, so the astronomers looked up to the galactic poles instead.

Over 2023, the team took nearly 200 exposures, each an hour long, of seemingly blank patches of sky, carefully calibrating the results to remove the signal produced by the camera's electronics themselves. The result of all this work is a measurement of the background that comes from distant galaxies, from distant stars in the Milky Way, plus the faint glow of hydrogen in our Galaxy's halo.

The intriguing bit is that the measured background is brighter by a factor of two than we'd expect from all those sources added together. There is in the Universe a source of ultraviolet light that we have not yet suspected was there. Could there be more faint galaxies than we think? Perhaps the Milky Way harbours a hidden reservoir of hot gas? Perhaps something even odder is lurking out there.

> ***"There is a source of ultraviolet light that we have not yet suspected was there. Could there be more faint galaxies than we think?"***

It's a proper cosmic mystery, as well as a reminder that being out in the dim outer reaches of the Solar System has its advantages.



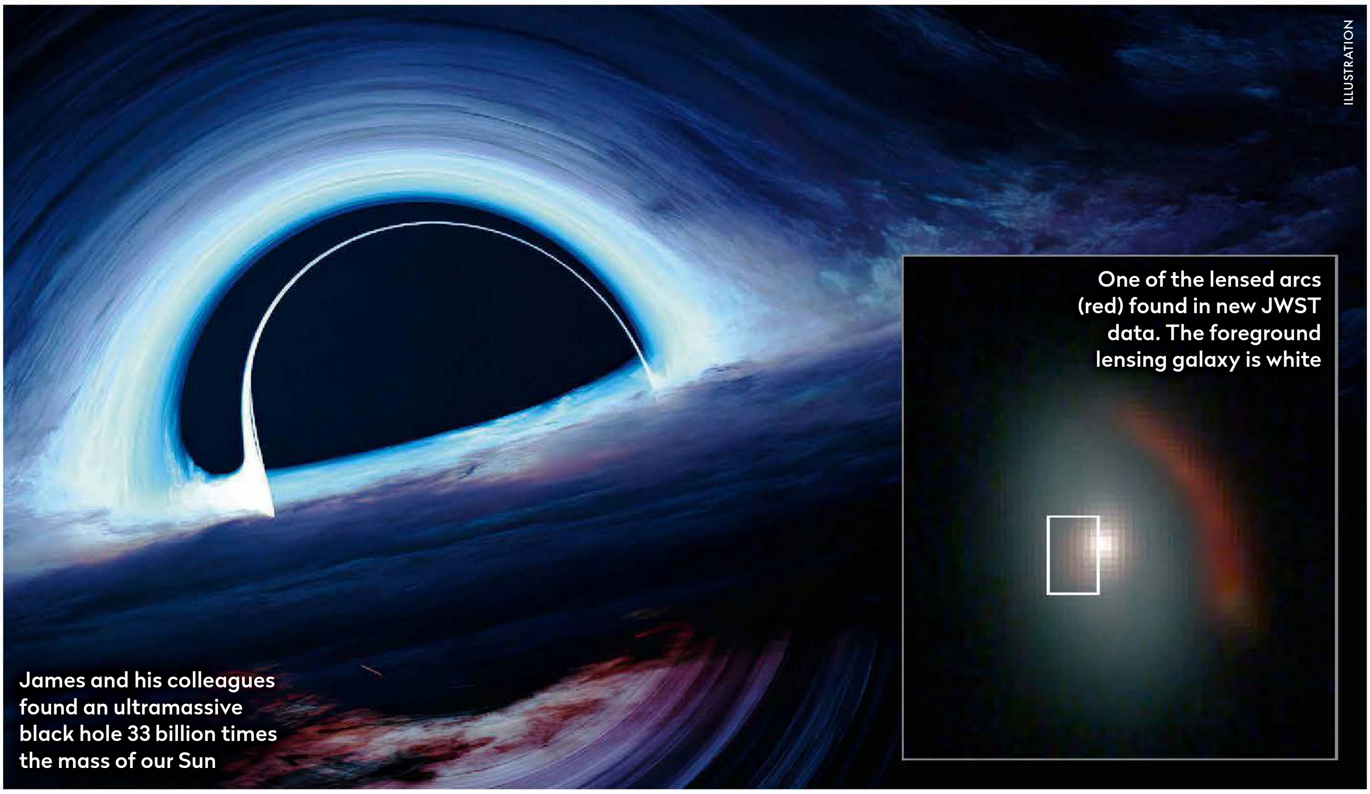
ILLUSTRATION

▲ **New Horizons found the cosmic ultraviolet background from apparently empty regions of space was at least double the brightness expected**

Chris Lintott was reading... *Excess Ultraviolet Emission at High Galactic Latitudes: A New Horizons View* by Jayant Murthy et al.
Read it online at: arxiv.org/abs/2501.00787

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT



One of the lensed arcs (red) found in new JWST data. The foreground lensing galaxy is white

James and his colleagues found an ultramassive black hole 33 billion times the mass of our Sun

Back in 2023, **James Nightingale** spoke to *The Sky at Night* about discovering one of the biggest black holes ever found. Now he tells us how the search for more has been going

Two years ago, I shared a groundbreaking discovery with *BBC Sky at Night* viewers and magazine readers: the first-ever use of gravitational lensing to uncover an ultramassive black hole, 33 billion times the mass of our Sun, at the heart of the galaxy Abell 1201.

Gravitational lensing, where the gravity of a massive foreground object bends and magnifies the light from a background galaxy, revealed this colossal black hole through the distinctive distortions of the background galaxy's image. This discovery demonstrated gravitational lensing could unveil some of the most massive black holes in existence, but could we use it to find other lenses?

Pivotal to the discovery was the unique geometry of the lens Abell 1201. The light from the background galaxy passed unusually close to the centre of the foreground lensing galaxy and the central black hole's immense gravity. This had never been observed in any other gravitational lens, so is this alignment truly rare or are current methods of identifying lenses unintentionally biased against such systems?

Traditionally, astronomers find lenses by visually spotting the distinctive arcs of the background galaxy. However, when the light passes so near to the lensing galaxy's core, they blend together, rendering it nearly impossible to see by eye.

JWST opens the goldmine

In 2023, the James Webb Space Telescope (JWST) conducted the COSMOS-Web survey, mapping the largest stretch of the Universe ever observed by the telescope and providing an unprecedented opportunity to uncover gravitational lenses. Equipped with its powerful 6.5-metre (21ft) mirror capable of capturing light from further into the cosmos than ever before, JWST unveiled hundreds of potential lenses.

Leading the effort to identify these systems, my team visually inspected over 40,000 images of the most massive galaxies. Unlike traditional methods, our analysis deliberately did not exclude candidates where the background galaxy's light might be obscured because it was heavily blended with the lens galaxy's core. By employing advanced image-

BLACK HOLE ILLUSTRATION: BLACKDOVFX/GETTY, JWST GRAVITATIONAL LENS IMAGE GOES TO GHASSEM GOZALIASL/ KAIJA VIROLAINEN/MAXIMILIEN FRANCO AND THE COSMOS-WEB COLLAOBRATION, NASA/JPL-CALTECH, BBC

processing techniques to separate and deblend their light, we could uncover these rare and elusive lensing configurations.

The inset image on the left showcases one lens we discovered, where the lensed images are influenced by the central black hole. A striking characteristic of these systems is the distinctly red hue of the lensed arcs, standing in sharp contrast to the whiter light of the foreground lensing galaxy. This vivid color contrast proved pivotal in identifying these lenses.

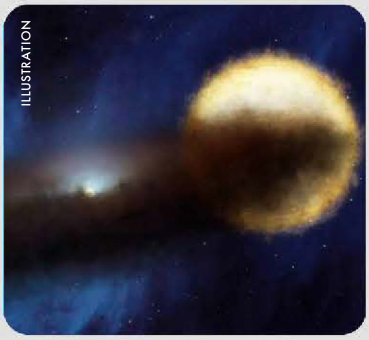
In total, the COSMOS-Web survey has uncovered at least five lenses that exhibit this unique configuration. Detailed analysis is now underway to understand what each system can reveal about their central supermassive black holes. In just two years, what was once considered a rare, one-off lens in Abell 1201 has become a common occurrence. This shift highlights a broader truth in astronomy: phenomena that initially seem unexpected and rare often turn out to be widespread and ordinary, once we know where and how to look for them.

James Nightingale is an observational cosmologist at Durham University, focusing on strong gravitational lensing

The Universe still holds countless surprises, and discoveries like these remind us that even the most extraordinary phenomena can be hiding in plain sight, waiting for those with the curiosity and determination to uncover them.

Looking back: The Sky at Night

20 March 1982



▲ Epsilon Aurigae's weird dimming may be due to a vast dust cloud

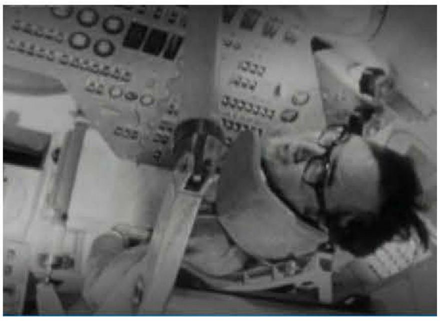
On the 20 March 1982 episode of *The Sky at Night*, Patrick Moore was taking a look at one of the most unusual stars in the night sky as it underwent a transformation that occurs once every three decades. Most of the time, Epsilon Aurigae (also known as Almaaz) looks like a very unassuming mag. +2.9 star. Then, once every 27 years, its brightness drops to mag. +3.8. It remains this dim echo of its normal self for around two years, before jumping back up in brightness again.

Astronomer Johann Heinrich Fritsch first noticed the dimming in 1821, but scientists are still not entirely certain what could be causing it. Infrared observations have shown evidence that the star is a binary system, so it's likely the dimming is due to this companion passing between Earth and the star and blocking out the light. What's not clear is what this companion could be.

At the time of the 1982 episode, one theory was that it was a black hole, but this has since been disproven. The current leading theory is that the companion is a relatively normal star surrounded by a cloud of dust around 20 times the Earth–Sun distance across. This would be large enough to block out a significant portion of the main star's light. Astronomers will have to wait to test this theory, however, as the next dimming isn't due until 2037. No doubt they're already planning their observations to find out exactly what's going on in Auriga.

Revisit the past with the BBC Archive

Relive the Space Race for yourself by diving into the BBC Archive, a collection of extracts from a variety of BBC shows, charting the biggest stories of the last few decades. Watch the BBC's report on the flight of John Glenn, the first American astronaut to circle the globe, the coverage from Houston on the eve of Apollo 11's launch and the reaction to Apollo 13 returning home safely after its disaster-struck mission, as well as dozens of other space-themed clips. Find them all at **bit.ly/ArchiveBBC**.



▲ Enjoy moments like James Burke's report from inside an Apollo capsule simulator

SPACE EXPLORATION

Signature® Auction | June 13-14

Now Accepting Consignments
Deadline April 14

APOLLO 13
APRIL 11-17, 1970
- OFF
ACR FA-5
SERIAL NO.1062
DATE OF MFG 7-68
"LIT MY WAY HOME"
FRED HAISE
APOLLO 13 LMP

Apollo 13 Lunar Module *Aquarius* Flown Flashlight
Directly from the Personal Collection of Lunar Module Pilot Fred Haise
with His Signed Letter of Authenticity
Sold for $106,250

INQUIRIES: 877- HERITAGE (437-4824)
Brad Palmer | Ext. 1185 | BradP@HA.com
HA.com/Space

HERITAGE
AUCTIONS

Paul R. Minshull #16591. BP 15-25%; see HA.com 82039

Emails – Letters – Tweets – Instagram

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

MESSAGE OF THE MONTH

Astronomy goes viral

▲ **15-year-old Travis has been getting lots of love online for shots like these of Jupiter, the Flame Nebula and the Whirlpool Galaxy**

My grandson Travis Key, who's 15, is an avid photographer of the stars, Moon and galaxies. He sits out in all weathers with his telescope until 4am, often to capture amazing photographs and videos. He has an amazing knowledge of the Solar System and Universe, but he's very unassuming about his hobby and talent to his friends and teachers at school. However, he has a large following on TikTok, with over 4.9 million views for one of his videos. Here (above) are some of the photographs that he took on New Year's night. It would mean the world if he could be featured in your magazine.

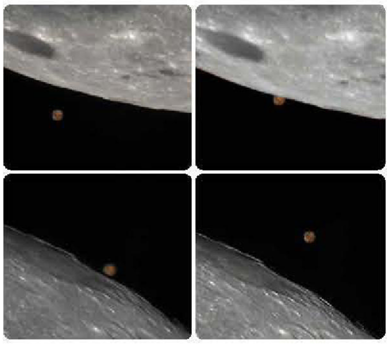
Catherine Glenton, via email

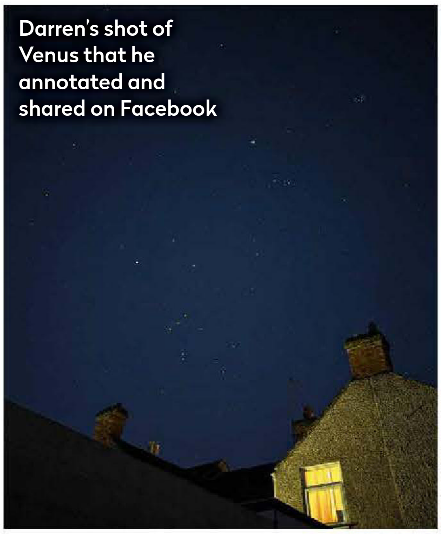
It's fantastic to hear his images are getting such good recognition. Well done on sharing your passion, Travis! ***– Ed.***

Tweet

James Willinghan
@JamesWillinghan • 14 January

#MarsOccultation Seeing was very poor with a strong part of the jet stream overhead. Taken with 132mm refractor, ASI224MC camera and 2.5x Powermate. Elkridge, MD. @skyatnightmag





Darren's shot of Venus that he annotated and shared on Facebook

Teaching moment

As my friends know I'm interested in astronomy, I had a few messages asking what the bright 'star' was next to the moon on 2 January. I replied to let them know it was Venus and, as it was clear outside, I decided to take a quick picture of a section of the night sky above my house in Swindon with my mobile phone (left) and share it on Facebook. It was quite popular and there were some lovely comments, even one from a teacher to say she'd be using it with her class. It was taken on my smartphone, by the way, a Google Pixel 7.

Darren Lee, Swindon

Depth charge

I'm a long-time subscriber and completed your survey a few months ago where I provided some feedback that I felt the astrophotography coverage seemed limited to fairly beginner topics like the 500 rule, using a phone camera, etc. I fully understand how important making the subject accessible is, but would love to ▶

BBC Sky at Night MAGAZINE

ourmedia

BBC Sky at Night Magazine is published by Our Media Ltd under licence from BBC Studios, which helps fund new BBC programmes.

EDITORIAL
Editor Chris Bramley
Content Editor Iain Todd
Features Editor Ezzy Pearson
Art Editor Steve Marsh
Senior Production Editor Jess Wilder
Reviews Editor Charlotte Daniels

CONTRIBUTORS
Stuart Atkinson, Paul Bogard, Anita Chandran, Lewis Dartnell, Glenn Dawes, Russell Deeks, Ben Evans, Mark Garlick, Pippa Goldschmidt, Jane Green, Peter Jenkins, Pete Lawrence, Chris Lintott, Paul Money, James Nightingale, Laura Nuttall, Ivana Peranic, Jonathan Powell, Katrin Raynor, Giles Sparrow

ADVERTISING SALES
Advertising Executive Andy Williams
+44 (0)117 300 8803, Andy.Williams@ourmedia.co.uk
Inserts Laurence Robertson +353 (0)87 690 2208

CONTENT OPERATIONS
Content Operations Director Sarah Powell
Senior Content Operations Coordinator Derrick Andrews
Head of Operations Jessica Mills
Ad Coordinator Charles Thurlow
Ad Designers Cee Pike, Andrew Hobson
Reprographics Chris Sutch

LICENSING
Director of International and Licensing Tim Hudson
Head of Licensing Tom Shaw
Head of Syndication Richard Bentley

MARKETING
Head of Customer Acquisition Clive Evans-Morris
Head of Loyalty, CRM and Retention Rosa Sherwood
Performance Marketing Manager Chris Rackley

PUBLISHING & MANAGEMENT
Brand Lead Rob Brock
Managing Director Andrew Davies
CEO Andy Marshall

BBC STUDIOS, UK PUBLISHING
SVP Global Licensing Stephen Davies
Global Director, Magazines Mandy Thwaites
Content Manager Cameron McEwan
UK.Publishing@bbc.com; www.bbcstudios.com

EDITORIAL REVIEW BOARD
Andrew Cohen, Head, BBC Studios Science Unit; Martin Smith, Executive Editor, BBC Radio Science Unit; Steve Crabtree, Executive Producer

SUBSCRIPTION RATES
Annual subscription rates (inc. P&P): UK cheque/credit card £62.40; Europe & Eire Airmail £75; rest of world airmail £85. To order, call 03330 162119 (UK); overseas +44 (0)1604 973727

ipso Regulated We abide by IPSO's rules and regulations. To give feedback about our magazines, please visit ourmedia.co.uk, email **editorialcomplaints@ourmedia.co.uk** or write to Legal, Our Media Ltd, Eagle House, Bristol, BS1 4ST.

abc Audit Bureau of Circulations
31,289 (combined, Jan–Dec 2023)

© Our Media Ltd 2025

ISSN 1745-9869

All rights reserved. No part of *BBC Sky at Night Magazine* may be reproduced in any form or by means either wholly or in part, without prior written permission of the publisher. Not to be re-sold, lent or hired out or otherwise disposed of by way of trade at more than the recommended retail price (subject to VAT in the Republic of Ireland) or in mutilated condition. Our Media Company is working to ensure that all of its paper comes from well-managed, FSC®-certified forests and other controlled sources. This magazine is printed on Forest Stewardship Council® (FSC®) certified paper. This magazine can be recycled for use in newspapers and packaging. Please remove any gifts, samples or wrapping and dispose of them at your local collection point.

FSC www.fsc.org MIX From responsible sources FSC® C015155

recycle

The publisher, editor and authors accept no responsibility in respect of any products, goods or services that may be advertised or referred to in this issue for any errors, omissions, mis-statements or mistakes in any such advertisements or references.

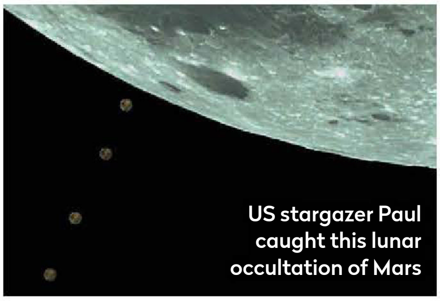
▶ see more in-depth content. I was delighted to see that the coverage of planetary versus deep-sky imaging ('Jump into the Deep End', January 2025) absolutely smashed this remit and mirrored what I'd be researching independently for months (thankfully!). Of course, this could all be coincidental, but whatever the reason, thank you for switching it up!

Michael Mallett, via email

Mars meets Moon

Since the UK got just a skimming close approach of Mars to the Moon in your early morning of 14 January, I thought I would offer this head-on occultation approach composite acquired on 13 January (local time) across the pond using a 6-inch Schmidt–Cassegrain with a ZWO ASI224MC. The sub-images were processed with start times of 21:16, 21:18, 21:21 and 21:24 EST (rounded to the nearest minute).

Paul Lahti, Massachusetts, USA


US stargazer Paul caught this lunar occultation of Mars

Instagram

dibbly86 • 3 January
Crescent Moon & Venus conjunction @bbcskyatnightmag

Seconds count

I thought I'd send this photo of the Sun taken with the Seestar S50 on 21 January. It's been a poor start to 2025 weatherwise, so one has to make the most of any break in the weather. This smart telescope can be quickly deployed and can get those fleeting moments. Here we have a set of sunspots seen through the breaking cloud.

Anton Matthews, via email

SOCIETY IN FOCUS

The **Amateur Astronomers Association of Pittsburgh**, Inc (AAAP) has been actively promoting popular astronomy since its founding in 1929. Currently, we have about 450 members who share a variety of interests such as visual observing, astrophotography, image processing, telescope making and educational outreach. Plans for our 100th anniversary celebration are in the preliminary stages, but will certainly involve special star parties and high-profile community activities in 2029.

We built and operate two small roll-off-roof observatories: Wagman, about 15 miles northeast of Pittsburgh, and Mingo, about 10 miles southwest of the city. Notable among the observatories' telescopes is the 110-year-old Brashear 11-inch refractor. We conduct monthly public star parties at these observatories, with attendance sometimes reaching as many as 500 guests.

An AAAP star party at the group's Mingo Observatory

In addition to observatory star parties, we conduct 15–20 off-site star parties each year at public libraries, community centres, primary and secondary schools, camps and municipal parks. Various types of portable telescopes are set up by members for these parties. The AAAP also collaborates with regional astronomy and space science institutions such as the University of Pittsburgh's Allegheny Observatory, the Kamin Science Center and Carnegie Mellon University.

Eric Fisher, AAAP newsletter editor and archivist

▶ **www.3ap.org**

Cruise ship? Or expedition base camp?

An expedition with HX isn't a sail-by that keeps you at a distance. With hikes, kayaking, and even camping, these are voyages that bring you deep into the beauty and wonder that is the seventh continent.

Change the way you see the world.

Up to
15% OFF*
All-inclusive Expeditions to
Antarctica
+ HX Price Promise**

Scan the QR code
to learn more

HURTIGRUTEN EXPEDITIONS

ANTARCTICA | ALASKA | GALÁPAGOS | GREENLAND | ICELAND |
NORTHWEST PASSAGE | NORWAY | SVALBARD

Call 0203 553 1608 | Visit travelhx.com

CRUISE COLLECTIVE

Join Cruise Collective for free and receive **5% OFF** your next adventure†

cruise-collective.com

Terms and conditions: *Discount represents a discount applied to the "From" price quoted in GBP per person based on full occupancy of cabin on the specified sailing and applies to valid Tour Codes and only to Tour Code components (including voyage and local domestic flights). Applies to bookings made from 19 December 2024 to 31 March 2025 (inclusive) for selected HX departures from 1 April 2025 and 31 March 2027 (inclusive). Bookings outside of these periods do not qualify. Offer is subject to availability and may be withdrawn at any time without prior notice. See our website for more details. Some excursions are an added cost. Single suapplements may apply and applies to all offer occupancies. Combinable with the HX Explorers loyalty program. **Price Promise valid for sailings between 1 April 2025 through 31 March 2027. Images: © Espen Mills
†T&Cs apply. See website for further details.

ABTA
Travel with confidence
ABTA No.Y6835

This was Sylvia's promise to you...

A generation ago, a woman named Sylvia made a promise. As a doctor's secretary, she'd watched stroke destroy the lives of so many people. She was determined to make sure we could all live in a world where we're far less likely to lose our lives to stroke.

She kept her promise, and a gift to the Stroke Association was included in her Will. Sylvia's gift helped fund the work that made sure many more of us survive stroke now than did in her lifetime.

Sylvia changed the story for us all. Now it's our turn to change the story for those who'll come after us.

Stroke still shatters lives and tears families apart. And surviving a stroke is just the start of a long and gruelling recovery journey. If you or someone you love has been affected by stroke – you'll know just what that means.

You can change the story, just like Sylvia did, with a gift in your Will. All it takes is a promise.

You can promise future generations a world where researchers discover new treatments and surgeries, and stroke survivors and their families have the support to find the strength and determination they need to find their way back to life.

Your promise today gives strength for tomorrow. Please, leave a gift in your Will to the Stroke Association.

Find out how by calling 020 7566 1505
or email legacy@stroke.org.uk
or visit stroke.org.uk/legacy

Finding **strength** through **support**

The Stroke Association is registered as a charity in England and Wales (No 211015) and in Scotland (SC037789).
Also registered in the Isle of Man (No. 945) and Jersey (NPO 369), and operating as a charity in Northern Ireland.

Stroke Association

The astronomer's forum

FIELD OF VIEW

Measuring up the Universe

Space doesn't just astound us, says **Jonathan Powell**. It's the mother of invention

WILD DUCK CLUSTER, SAGITTARIUS ARM, MILKY WAY:
36,000,000,000,000,000 MILES

The scale of the Universe generates numbers that defy our comprehension. But don't think for a second that an inability to grasp the scale that such staggering figures represent is a failing. Think of it instead as an inspiration to evolve our technological capabilities until they span these cosmic gulfs, just like when we took that very first lunar step.

Advances in several technologies allowed us to reach the Moon and, one day in the future, could see us set foot on Mars. But to develop a rocket with enough thrust, you must first measure the distance to your target, and that skill has its roots in being able to measure the size of our home planet.

In ancient Greece, Eratosthenes, chief librarian at the Library of Alexandria, made one of the first well-researched attempts to calculate Earth's circumference. He had read that at noon on the summer solstice in the city of Syene (modern Aswan), a vertical pole cast no shadow. He also knew the distance between Syene and Alexandria (800km; 500 miles), since the ancient Greeks checked it each year.

By measuring the length of a pole and its shadow at noon on the summer solstice in Alexandria, he found the angle of the Sun's rays there was 7°. Since 7° is 1/50 of a circle, he concluded that Earth's circumference was 50 times the distance between the two cities, or 40,000km (25,000 miles) – which is only 100 miles off the actual circumference.

While such measurements made in kilometres or miles on Earth work effectively enough, beyond our planet a different set of units are needed to tackle the greater distances encountered. Lunar distance, the astronomical unit (AU), lightyears, parsecs and standard candles are all designed to measure progressively larger distances across the Universe.

But those units only work out to around a thousand parsecs, or 3,260 lightyears, from Earth. What's to be done with the rest of the observable Universe, which is an unfathomable 93 billion lightyears in diameter? There's no single technique that will cover a distance this vast. Instead, astronomers use something called the cosmic distance ladder to measure distances stretching further and further across the Universe, with each step building on the previous step's accuracy.

It starts with parallax, checking how nearby stars shift as Earth orbits the Sun. For more distant stars, we rely on Cepheid variable stars, the Universe's blinking distance signs, and Type Ia supernovae, which explode with predictable brightness (those standard candles). To measure galaxies, we use redshift, where their light's wavelength stretches to the red end of the spectrum like a cosmic rubber band. Each method builds on the last, creating a ladder that's shaky but functional. It's essential for mapping the Universe and proving that, yes, space really is mind-bogglingly huge.

And that's before we consider the by-product that all this measuring produces: the understanding that when we look further across these immense distances, we also look back in time! These staggering distances are the Universe's own evolutionary archives, an incredible record of the past catalogued by light itself.

Jonathan Powell is a freelance writer and broadcaster. A former correspondent at BBC Radio Wales, he is astronomy columnist at the *South Wales Argus*

ALAN DYER/STOCKTREK IMAGES/GETTY

BBC
Sky at Night
MAGAZINE

SAVE WHEN YOU SUBSCRIBE
TO THE DIGITAL EDITION

BBC
WHAT TO DO IF YOU'VE FOUND A METEORITE
#237 FEBRUARY 2025
Sky at Night
THE UK'S BEST-SELLING ASTRONOMY MAGAZINE
A UNIVERSE WITHOUT
GRAVITY
How nature's weakest force does far more than keep our feet on the ground
WHAT SCI-FI MOVIES GET WRONG ABOUT SPACE
AI & ASTROPHOTOGRAPHY: FRIENDS OR FOES?
ON TEST: STARFIELD OPTICS' NEW 4-ELEMENT REFRACTOR
RARE TRIPLE-ECLIPSING STAR SETS NEW RECORD
CATCH THE CRESCENT: VENUS LIGHTS UP EVENING SKIES
PLUS: WHAT TO DO IF YOU'VE FOUND A METEORITE

Available from

Download on the App Store

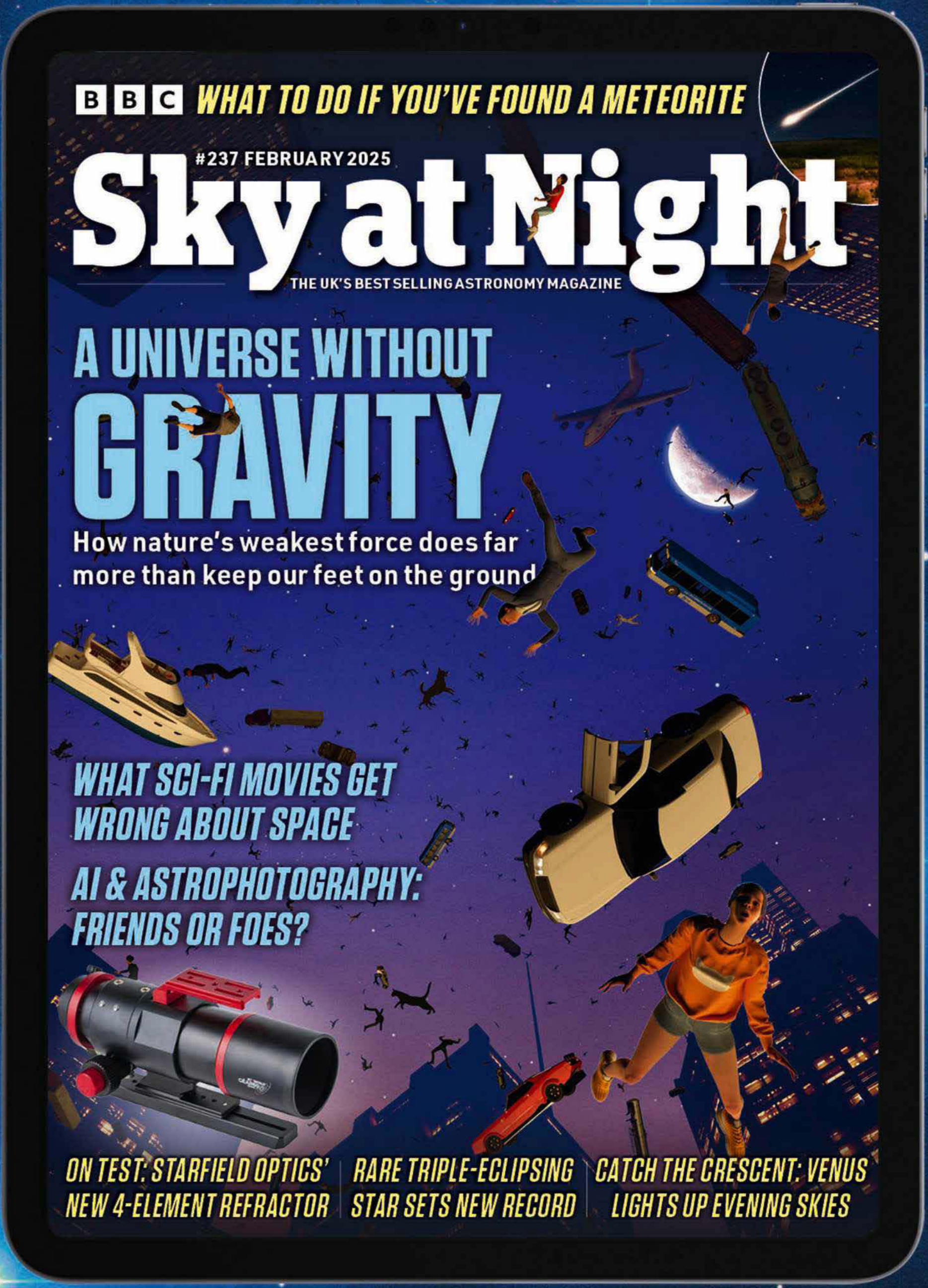
amazon apps Available on kindle fire

GET IT ON Google play

zinio™

News

The perfect addition to your stargazing, *BBC Sky at Night Magazine* is your practical guide to astronomy, helping you to discover the night skies, understand the Universe around us and learn exciting techniques for using your telescope.


BBC
WHAT TO DO IF YOU'VE FOUND A METEORITE
#237 FEBRUARY 2025
Sky at Night
THE UK'S BEST SELLING ASTRONOMY MAGAZINE
A UNIVERSE WITHOUT GRAVITY
How nature's weakest force does far more than keep our feet on the ground
WHAT SCI-FI MOVIES GET WRONG ABOUT SPACE
AI & ASTROPHOTOGRAPHY: FRIENDS OR FOES?
ON TEST: STARFIELD OPTICS' NEW 4-ELEMENT REFRACTOR
RARE TRIPLE-ECLIPSING STAR SETS NEW RECORD
CATCH THE CRESCENT: VENUS LIGHTS UP EVENING SKIES

Enjoy our Premium App experience
now available from

News

NASA/JPL-CALTECH/MSSS

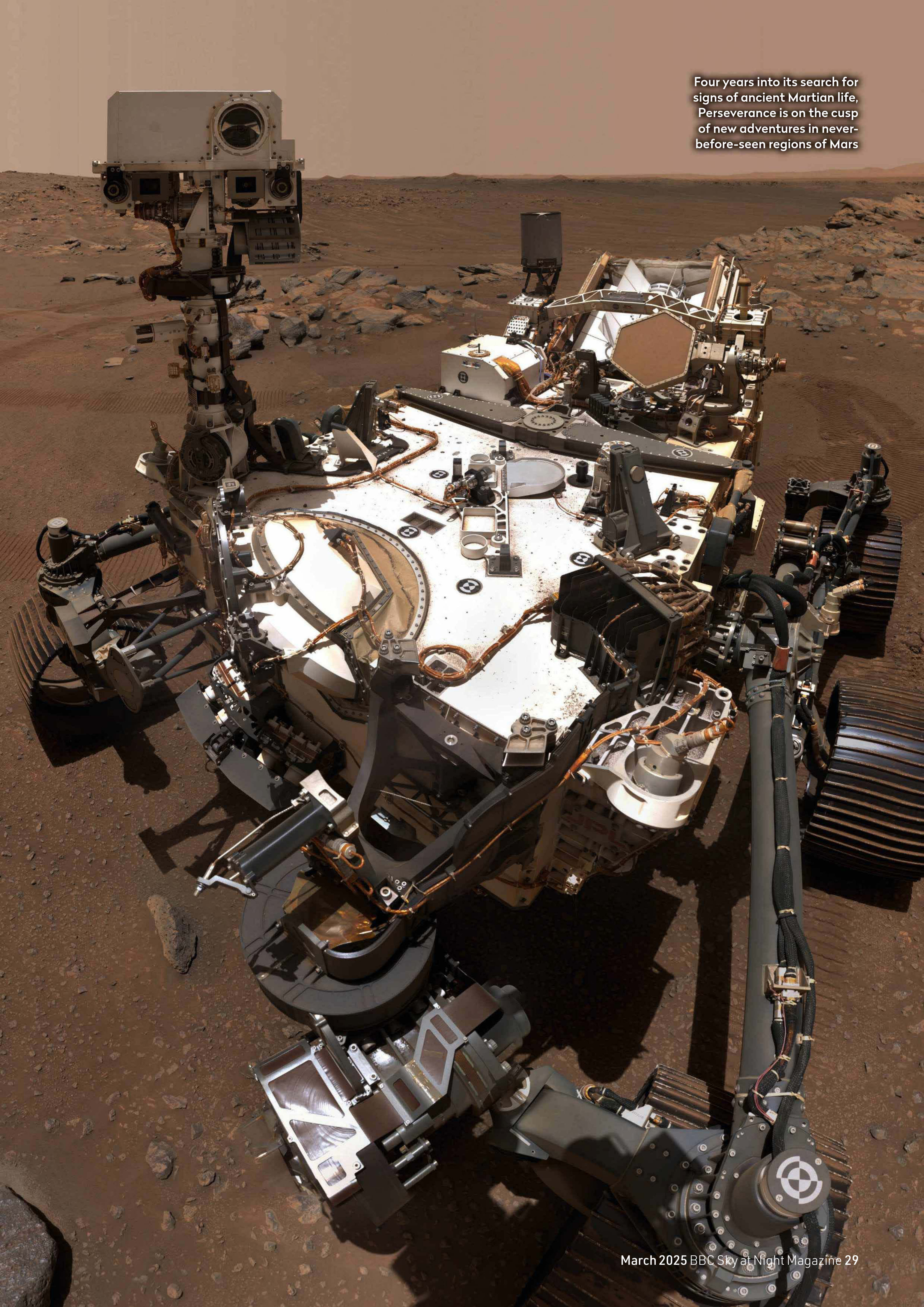
Perseverance: *the story so far*

As the Mars rover begins a new era of discovery beyond Jezero Crater, **Stuart Atkinson** takes a look back at the robot explorer's triumphs to date

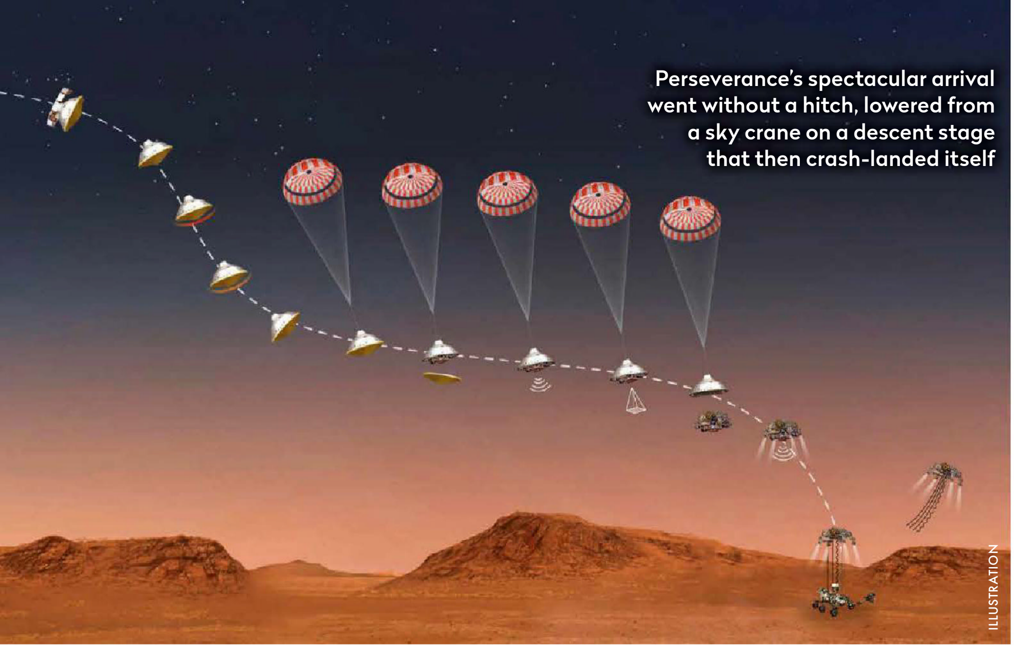
If you'd been standing on the floor of Jezero Crater on Mars on 18 February 2021, you'd have seen a strange sight: a large vehicle falling out of the peach-hued sky, swinging on the end of a metal line, hanging beneath a Thunderbirds-style contraption that looked more like a huge flying bedstead than a spacecraft. This was the Perseverance rover, a nuclear-powered geologist-biologist sent from Earth to look for signs of ancient Martian life.

At the end of 2024, the rover finally left Jezero Crater, ready to start the next phase of its mission. But how did it get there and what has it learned over the past four years?

Perseverance was sent to Jezero mainly because the crater contained an ancient river delta, a broad fan of sedimentary material washed into it from the surrounding area by floods billions of years ago. Here on Earth, river deltas are known to trap and preserve organic materials, making them excellent places to search for signs of ancient life. Jezero also contained clay minerals, suggesting that water had been present in the crater for a long period, providing ▶

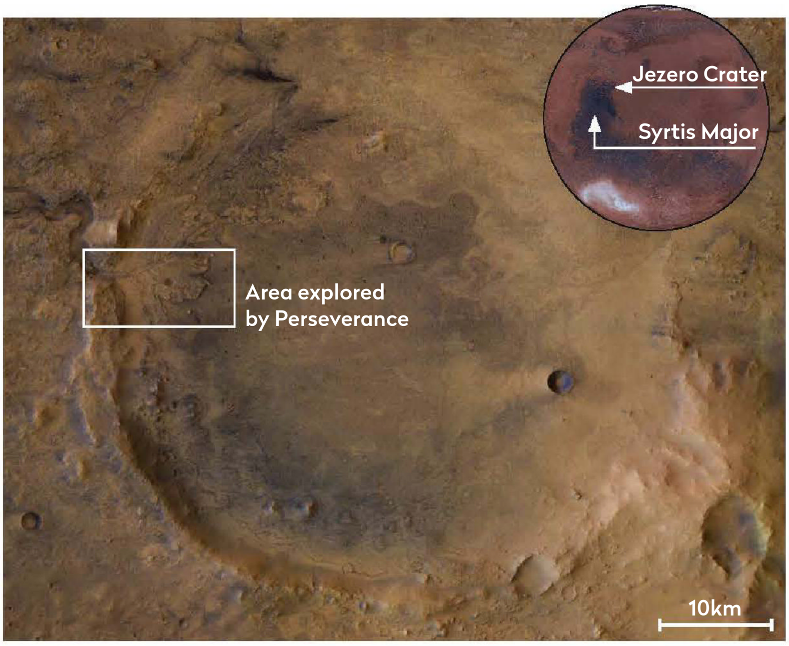


Four years into its search for signs of ancient Martian life, Perseverance is on the cusp of new adventures in never-before-seen regions of Mars


Perseverance's spectacular arrival went without a hitch, lowered from a sky crane on a descent stage that then crash-landed itself

High drifting clouds in a blue Martian sunrise, captured by the rover in March 2023

A Mars sunset captured by Mastcam-Z, one of 19 cameras on board, along with seven primary science instruments



▲ Scientists chose the channel that fed Jezero Crater as the most likely area to contain signs of ancient life from Mars's wet past

▶ a potentially habitable environment for microbial life. The crater's flat terrain and lack of large boulders also offered Perseverance a safe landing site.

After landing on Mars, Perseverance set off across Jezero's floor, ready to begin the first of several planned science campaigns. With a top speed of 0.1km/h (0.06mph), Perseverance is hardly a racing car, but that's more than fast enough for a robot scientist exploring an alien world. And before it could pull on a lab coat, gloves and goggles, it also had to drop off its hitchhiker, a small robot helicopter called Ingenuity.

Rover plays fetch

By June, Perseverance had begun exploring the floor of Jezero Crater, stopping regularly to photograph the rocks around it, but the front of the delta, with its layers of sediment, beckoned, and soon the rover headed for the horizon.

On the way to the delta, Perseverance began using its sophisticated drill to take samples of Martian rock and dust, depositing them into sample tubes and storing them safely on board. The plan is for these priceless sample tubes to be returned to Earth in the future, but plans for this Mars sample-return mission have fallen into disarray. NASA deemed the original plan too complicated, too expensive and too slow, so a rethink was ordered (see box, opposite).

It was during this stage of the mission that Perseverance finally turned the dreams of generations of Mars scientists and enthusiasts into reality. As well as carrying a shopful of cameras and a small laboratory's worth of scientific instruments and equipment, the rover is carrying something else: a microphone designed to record the sounds of Mars. On 20 February 2021, the mic was turned on for the first time. You might think there's no sound to be heard on an airless, lifeless world like Mars, but Perseverance recorded the ghostly whispers of wind gusts and the clanking and squeaking of her own wheels and instruments as she trundled across the rocky landscape. You can listen to these historic recordings yourself by going to the mission's website.

Another of the mission's greatest achievements came in April 2021, when the Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE) was turned on. MOXIE's crucial task was to suck in the cold, dry Martian air and see if it could produce oxygen from it – and it worked. At its most efficient, MOXIE

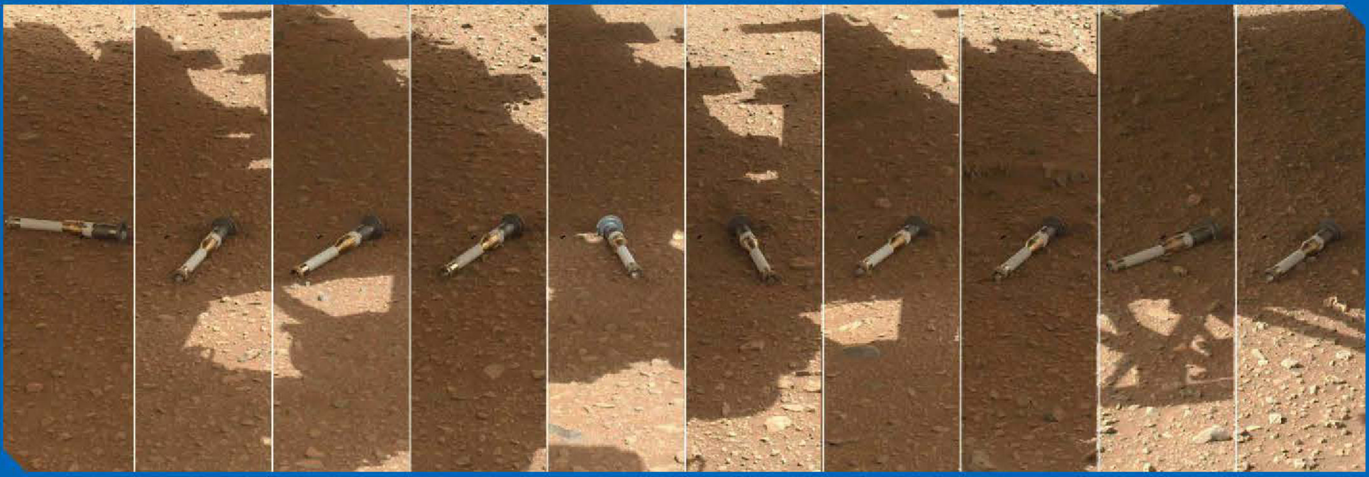
NASA/JPL-CALTECH X 2, NASA/JPL-CALTECH/ASU/MSSS, ESA/DLR/FU BERLIN, NASA AMES/USGS/JPL/CORRINE ROJAS,
NASA/JPL-CALTECH/MSSS, NASA/JPL-CALTECH/LANL/CNES/CNRS/INTA-CSIC/SPACE SCIENCE INSTITUTE/ISAE-SUPAERO

How to return a sample from Mars

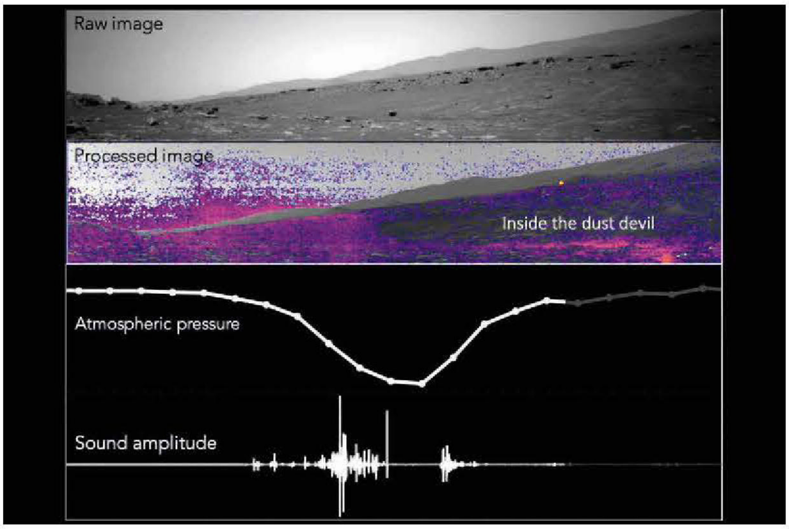
The question of how we'll retrieve Perseverance's cache remains unanswered

By the time it rolled over the rim of Jezero Crater, Perseverance had taken 18 priceless samples of rock and dust, storing them in metal tubes that look like a cross between lightsabers and giant spark plugs. The eight most important tubes are stored safely onboard the rover, but 10 'backup' samples were left at a site called Three Forks. Like a farmer planting seeds, Perseverance carefully dropped the precious tubes onto the ground one by one, spaced well apart, creating what NASA christened a sample depot. But what's going to happen to all these tubes?

The original plan was for a complicated joint NASA/ESA mission to retrieve them using a new lander, a pair of Ingenuity-like helicopters and an ascent vehicle to blast off the surface of Mars carrying the tubes up to yet another spacecraft which would eventually return them to Earth. But delays and rocketing costs prompted a fundamental rethink at NASA. In early January 2025, the agency announced it was planning a cheaper and much less complicated mission, possibly involving private companies, to return the samples in 2035. A final decision on the way forward will be taken in 2026.



▲ Gathering dust: the 10 tubes of Martian material left at Three Forks within Jezero Crater, with no immediate prospect of return to Earth



▲ **Perseverance's SuperCam made the first-ever audio recordings of another world – this one is a dust devil passing over**

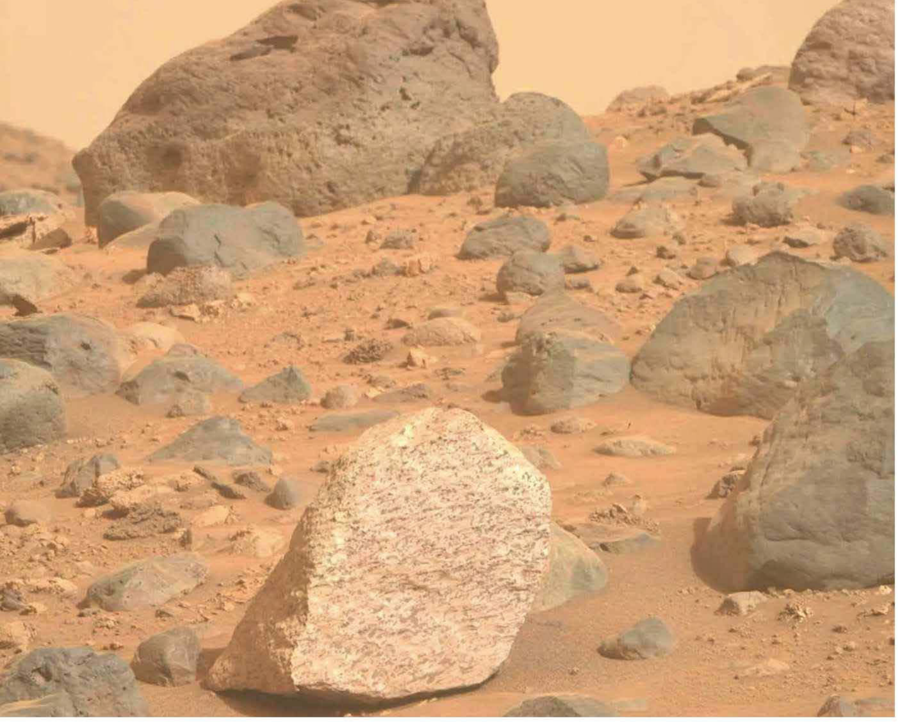
produced an amazing 12 grams (0.4oz) of oxygen per hour, twice as much as NASA originally aimed for. This proved that the Martian atmosphere can be used on future crewed missions to produce oxygen to breathe and use as rocket fuel, greatly reducing the amount of oxygen needed to be brought from Earth.

By December 2022, after skirting around craters and dust-trap dune fields, Perseverance finally reached the front edge of the river delta and began working her way along it. As she drove along in the shadow of the delta, Perseverance looked up and photographed its layers, ridges and outcrops in great detail. The rover carries 23 cameras, all of which serve various scientific, engineering and navigational purposes. The twin Mastcam-Z cameras are its most powerful, used to take the highest-resolution panoramic and stereoscopic images ever captured on Mars, while the lower-resolution Navcams and Hazcams have helped the rover drivers plan their routes. Other cameras such as the Supercam and SHERLOC have allowed Perseverance to take extreme close-ups of Martian rocks and features, zooming in on colourful crystals and mineral deposits tantalisingly suggestive of organic processes.

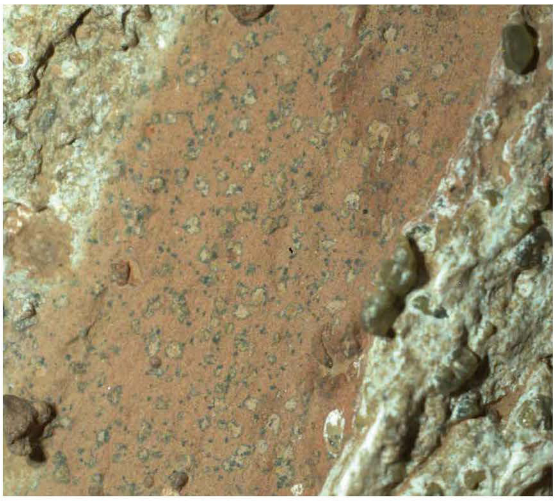
Eventually, Perseverance's work on the front edge of the delta was done and its drivers steered it carefully up from the crater floor and onto the top of the delta to begin another science campaign. Here, on the top of the delta, Perseverance was able to study rocks, minerals and structures totally different to the ones on the crater floor.

No stone unturned

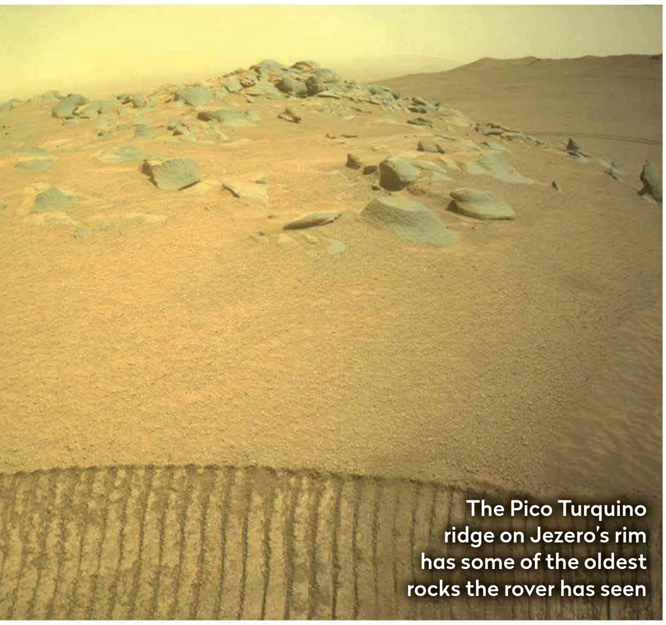
Driving up a narrow valley into an area christened Bright Angel, the rover found rocks with intriguing sharp ridges crossing them. Just like a human geologist would do, Perseverance cleaned the dust off the weathered surface of the rocks with its ▶



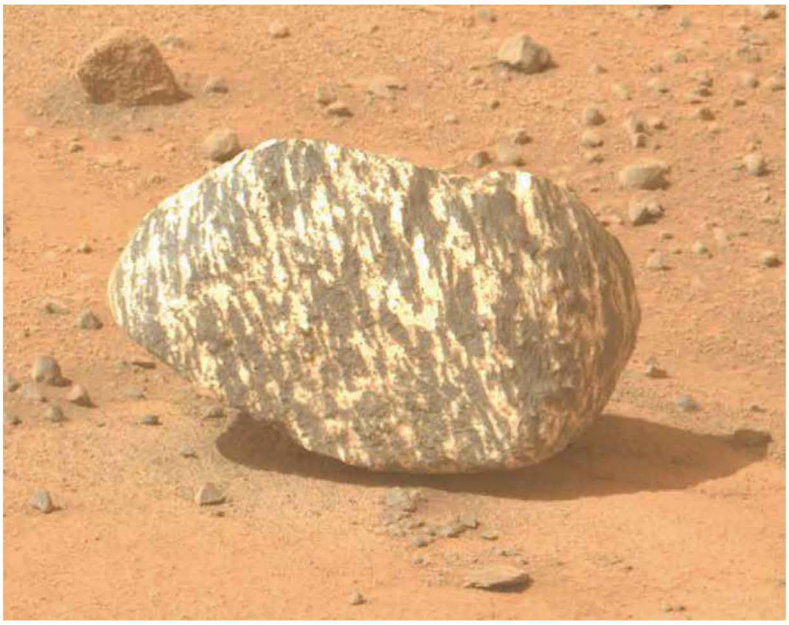
▲ Rare rock: the intriguing bright boulder dubbed Atoko Point, found in a field of wholly dark rocks in the Mount Washburn area, has baffled the rover team



▲ The veins and spots in the Cheyava Falls rock caused great excitement as possible indicators of ancient life



The Pico Turquino ridge on Jezero's rim has some of the oldest rocks the rover has seen



▲ Black-and-white striped Freya Castle has a texture unlike any other rock seen in the crater

▶ wire brushes and then drilled into them, exposing the pristine, ancient material beneath. The images Perseverance sent back of one of these rocks, christened Cheyava Falls, had scientists back on Earth leaning forwards in their seats with excitement – there were small, dark 'leopard spots' within them, surrounded by shells or crusts of lighter material, which looked very familiar. Here on Earth, such structures are often formed by primitive forms of life. Had Perseverance found evidence of life on Mars? It's unlikely – these structures can be formed naturally too, by purely geological processes – but scientists are very keen to study the samples collected by the rover to take a much closer look.

Having worked its way up the valley, after investigating a wide variety of rocks and leaving 10 of its precious sample tubes on the dusty ground to be picked up by its successor at some point in the future, Perseverance then set its sights on a new goal. Like its predecessors, the plucky golf-cart-sized Mars Exploration Rovers Spirit and Opportunity, and its little sibling Curiosity, Perseverance now heard the siren call of the hill summits surrounding it, and began to climb up the rim of Jezero Crater.

Leaving Jezero

Slowly but surely, like a seasoned hiker, Perseverance worked its way up the steep slope, heading for the distant summit. In mid-September 2024, it spotted something up ahead unlike anything it had seen before. In stark contrast to the uniformly beige and tan rocks around it, the chalky-pale, 20cm-wide rock off to the side of its route uphill was crisscrossed by darker stripes, like a piece of Martian candy.

Perseverance took many detailed photos of this bizarre rock – named Freya Castle by the rover team and thought to have rolled down the slope from outcrops much further uphill – before continuing on its way up the crater rim.

Looking back down on the floor of Jezero Crater and the ancient river delta it had explored and studied so carefully, it paused a while to study a large,

NASA/JPL-CALTECH/ASU X 2, NASA/JPL-CALTECH/MSSS, NASA/JPL-CALTECH X 2, NASA/JPL-CALTECH/ASU/MSSS, NASA

Stuart Atkinson is a lifelong amateur astronomer and author of 11 books on astronomy and spaceflight

Where next for Perseverance?

The rover's new Northern Rim campaign should bring exciting scientific riches

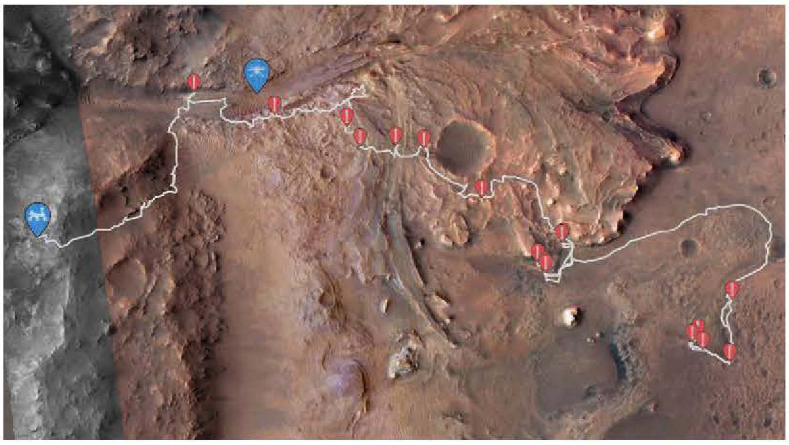
After a challenging 3.5-month journey up slopes with gradients as steep as 20 per cent to arrive at Lookout Hill and the rim of Jezero Crater, Perseverance has begun its next phase of operations. Its fifth science campaign, dubbed 'Northern Rim', starts with an area called Witch Hazel Hill, and the rover has already begun the 450-metre (1,500ft) journey towards this layered rocky outcrop.

A feature unlike anything seen inside Jezero Crater, 100-metre-long (330ft) Witch Hazel Hill represents rocks from Mars's early crust. During the impact that created Jezero Crater 3.9 billion years ago, huge chunks of rock like it, from deep underground, were lifted to the surface, making it some of the oldest exposed bedrock on Mars.

Each of the outcrop's layers was laid down at a different time in the planet's history. As Perseverance drives along the slope it will become a time machine, using data gleaned from each layer to explore the deep history of Mars's climate and geology.

After driving down Witch Hazel Hill, the rover will then turn away from the rim and journey 3km (2 miles) to the south, to the plains. In these grand, sweeping expanses unaffected by the impact that created Jezero, Perseverance has two further scientific stop-offs planned.

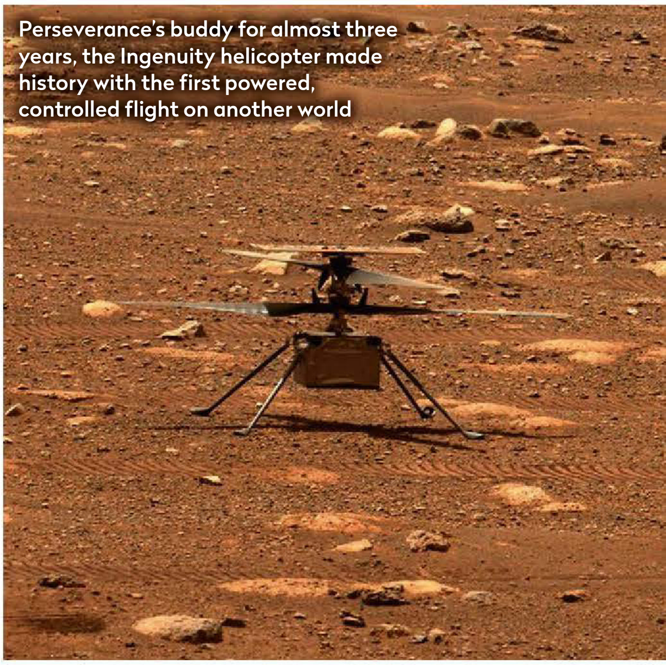
▲ Now out of the crater, Perseverance faces a steep descent to new terrain where the team expect to find rocks from deep down inside Mars



▲ Perseverance's route out of Jezero, showing where it gathered samples (red). Also shown is Ingenuity's resting place after it was damaged on its 72nd flight

layered outcrop christened Pico Turquino, sticking up out of the dusty ground like the fossilised bones of some ancient Martian dinosaur, before striking out for the summit.

On 10 December, after a hike of four months, Perseverance finally rolled up onto a small, flat area at the top of the crater rim, an area called Lookout Hill. From there, the rover had a quite spectacular view. Behind it was the rolling landscape it had driven through after landing. To the southeast was a previously hidden array of mesas, buttes and valleys close to the crater's far side. And ahead of it, on the other side of the crater rim, a whole new area of Mars that was until then obscured from Perseverance's curious eyes by the steep wall of the crater rim, was now in view, lit by the morning Sun.



Perseverance's buddy for almost three years, the Ingenuity helicopter made history with the first powered, controlled flight on another world

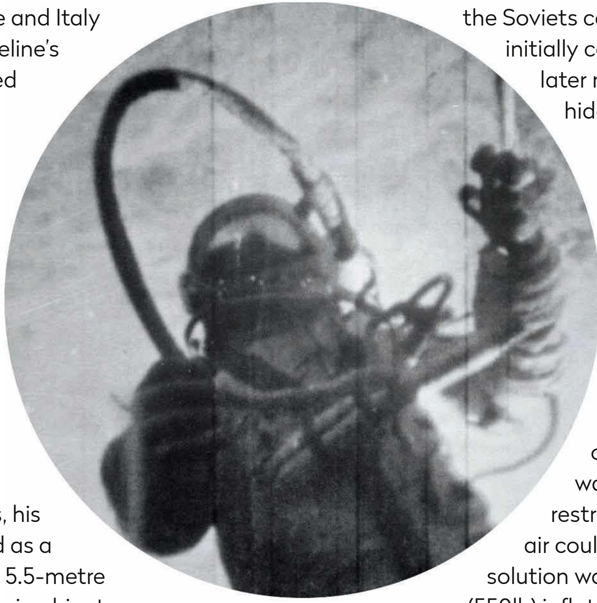
Like any hillwalker on Earth, the rover paused at the summit to drink in the view and take a sweeping high-resolution panoramic image of the landscape, before starting the long drive down the other side, towards a region of Mars never seen or explored before.

Beyond the airlock: *60 years of spacewalks*

What's it like to float in the lethal vacuum of space? **Ben Evans** tells the story of those who've stepped out of the airlock in the last six decades

The faceless figure tumbles in the half-light, arms flailing, helmet gleaming in the Sun's glare. Below, like a living map devoid of borders, lie the intense blues of the Mediterranean, the rolling greens and tans of Greece and Italy and, further east at his eyeline's periphery, the snow-dusted peaks of the Caucasus. Never before has a human's unhindered gaze seen so much or so far with such clarity, as half of planet Earth comes into view.

Sixty years ago, this beguiling sight captivated Soviet cosmonaut Alexei Leonov, the first person to 'walk' in space. With stiff-limbed awkwardness, his spacesuit pressurised rigid as a board, he fiddled with the 5.5-metre (18ft) umbilical cable tethering him to the Voskhod 2 capsule. But his euphoria wouldn't last, and soon he'd be forced to break every rule in the book to survive.



▲ **Keen to pip the USA to the post, Alexei Leonov exited the Voskhod 2 capsule on 18 March 1965**

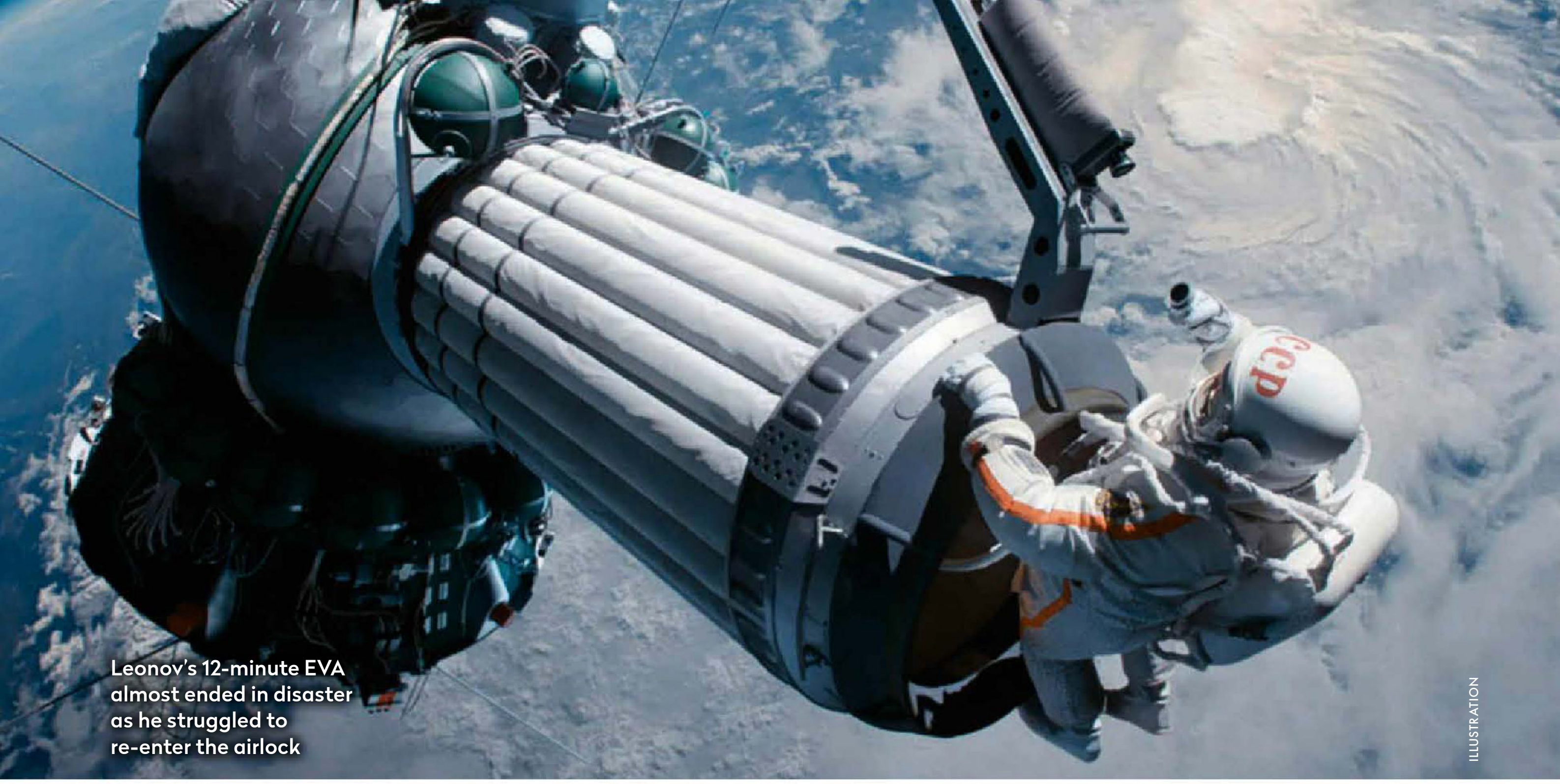
BETTMANN/GETTY, NASA

The first steps

The need for spacewalking was driven by the Moon race between the USA and Soviet Russia. Working on the airless, radiation-drenched lunar surface made extravehicular activity (EVA) essential, so NASA planned multiple spacewalks in Earth orbit during Project Gemini to prove humans could operate in this environment. Eager to beat the Americans, the Soviets conceived their own EVA, initially called Vykhod ('exit') but later renamed Voskhod 2 to hide its true nature.

Gemini's solid-state avionics and pure-oxygen atmosphere allowed astronauts to depressurise the cabin and then repressurise it after the EVA. But Voskhod needed continuous air cooling and would rapidly overheat if the cabin was depressurised. Weight restrictions also meant extra air couldn't be carried. The Soviet solution was an airlock, a 250kg (550lb) inflatable fabric cylinder, the Volga. But the risks were immense. Chief designer Sergei Korolev asked Leonov and Voskhod 2 commander Pavel Belyayev for their opinion, before adding that US astronaut Ed White would perform an EVA very soon. "He knew how to get our competitive juices flowing," Leonov wrote. ▶

More than 260 people have now taken the leap of faith and ventured from the safety of their spacecraft into the airless void


Leonov's 12-minute EVA almost ended in disaster as he struggled to re-enter the airlock

ILLUSTRATION

▶ Voskhod 2 was launched on 18 March 1965. An hour after reaching space, Belyayev started inflating the Volga and within minutes the airlock expanded into a rigid edifice 2.5 metres (8.2ft) long and 1.2 metres (4ftm) wide. Leonov's 41kg (90lb) spacesuit, the Berkut ('golden eagle') had a gold-tinted visor to cut solar glare and a Swiss camera on its chest, a switch sewn into its right thigh. But that switch lay just beyond the cosmonaut's reach and the only pictures of the first spacewalk came from grainy automatic cameras.

Belyayev clapped Leonov on the back and uttered one word: "Go!". Entering the Volga, Leonov closed the inner hatch and began depressurisation. He opened the outer hatch and pushed himself outside. "When it opened, I was lying on my back," he wrote. "There wasn't enough space to turn or move much." Leonov floated into space. "A tiny ant," he recalled, "compared to the immensity of the Universe." As Voskhod 2 passed within range of the Yevpatoria ground station, the first ghostly images were transmitted to a rapt world.

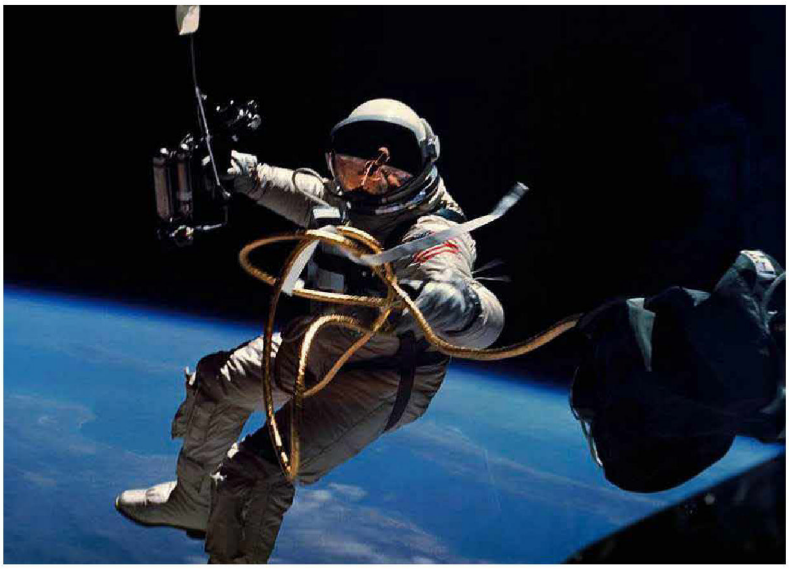
The spacewalk ended over Siberia, but Leonov's exertions caused the suit to balloon, rendering it impossible to re-enter the airlock feet first as planned. His only option was to breach mission rules: bleeding off oxygen to relieve pressure, then diving headfirst into the airlock.

By now up to his knees in sweat, Leonov's core body temperature rose by 1.8°C (3.2°F), threatening heatstroke. Turning inside the airlock demanded "tremendous effort", but he managed to close the outer hatch and started repressurisation. After 12 minutes, humanity's first spacewalk was over.

Trailblazers turn into a torrent

Three months later, Ed White completed the USA's first spacewalk. Jump to today, and 243 men and 23 women from 12 nations have made 479 spacewalks in Earth orbit, in deep space and on the Moon.

Spacewalks are a vital part of human spaceflight. Between 1998 and 2024, 272 spacewalks built and maintained the International Space Station. Spacewalkers added new modules, replaced batteries, upgraded solar arrays and rewired power grids. They carried out critical repairs and fixed ammonia and coolant leaks.

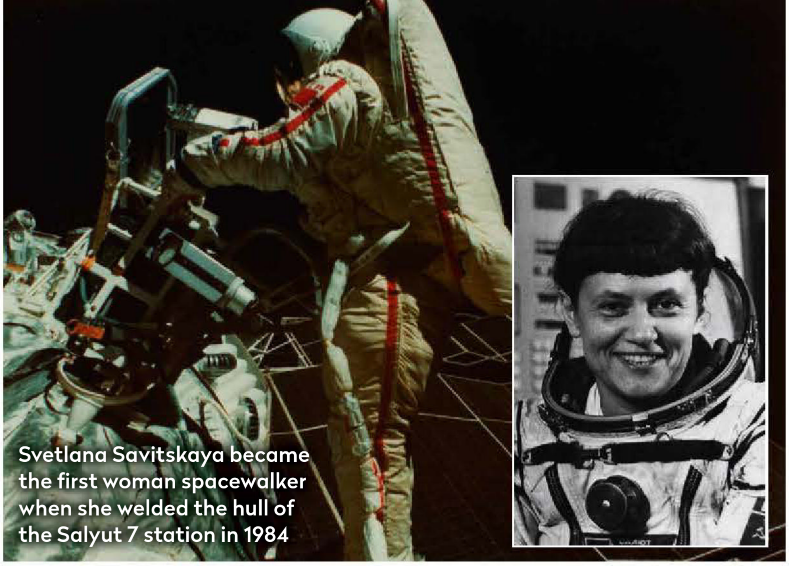

▲ Just weeks after Leonov, Ed White floated out of Gemini 4 to become the first American to undertake an EVA

Twenty-three spacewalks between 1993 and 2009 serviced the Hubble Space Telescope, adding new optics to correct its blurred vision, changing instruments, replacing gyroscopes, computers and solar arrays, patching insulation and doubling its life. It continues to dazzle into a fourth decade of service.

Ten spacewalks at the US Skylab space station in 1973–1974 added protective solar shields and retrieved camera films. Russian space station EVAs – three at Salyut 6 in 1977–1979, 13 at Salyut 7 in 1982–1986 and 80 at Mir in 1987–2000 – installed solar arrays and cranes, serviced leaking propulsion systems and inspected damaged modules. The final Mir spacewalk was the first to be privately funded.

After Zhai Zhigang made China's first spacewalk in 2008, 17 further EVAs at the Tiangong space station in 2021–2024 assembled a robotic arm, fitted thermal control pumps, inspected solar arrays and installed space debris protection equipment.

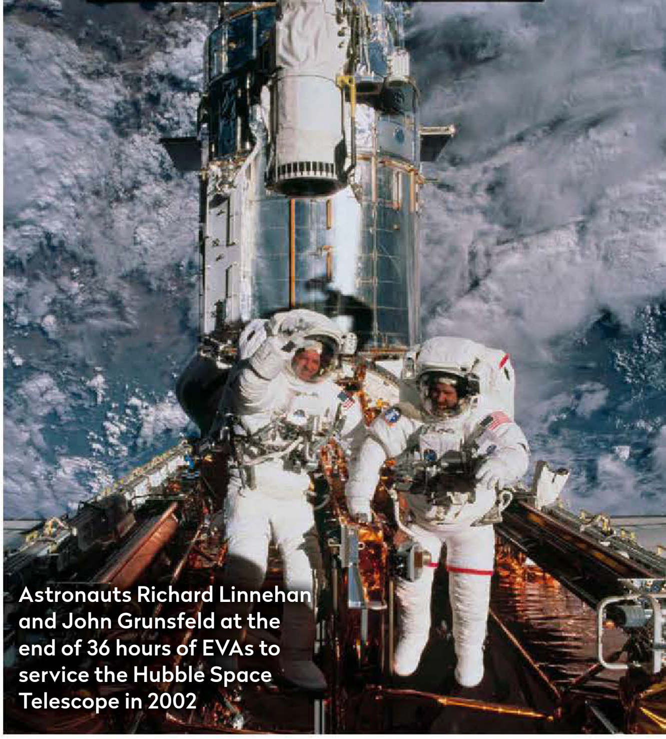
TCD/PROD.DB/ALAMY STOCK PHOTO, NASA X 3, ROGER RESSMEYER/ CORBIS/VCG VIA GETTY IMAGES, BETTMANN/GETTY



Svetlana Savitskaya became the first woman spacewalker when she welded the hull of the Salyut 7 station in 1984

▲ **Jessica Meir (left) and Christina Koch (right) made history with the first all-female EVA in October 2019**

Training for a spacewalk entails a mix of parabolic aircraft flights, altitude chambers, virtual-reality exercises and frictionless air-bearing tables to simulate weightlessness and improve spatial and situational awareness. Large water tanks like Russia's Hydrolab at Star City, near Moscow, Germany's Neutral Buoyancy Facility at Cologne and NASA's 28-million-litre (6.2-million-gallon) Neutral Buoyancy Laboratory in Houston, Texas, afford the nearest experience to the real thing.



Astronauts Richard Linnehan and John Grunsfeld at the end of 36 hours of EVAs to service the Hubble Space Telescope in 2002

To date, 85 per cent of spacewalkers have been Russian or American. But others have joined this EVA 'club': France in 1988, Germany in 1995, Japan in 1997, Switzerland in 1999, Canada in 2001, Sweden in 2006, China in 2008, Italy in 2013, the UK in 2016 and UAE in 2023. The club's members represent 0.000003 per cent of Earth's eight billion humans.

New-generation spacewalkers

Yet just 9.3 per cent of spacewalkers are women. The first female EVA, lasting three hours and 34 minutes, was by Russia's Svetlana Savitskaya in 1984. Since then, US, Chinese and Italian women have upgraded Hubble and assembled space stations, and in 2019 Christina Koch and Jessica Meir completed the first all-female EVA, lasting seven hours and 17 minutes.

Spacewalkers' ages range from 30-year-old Sarah Gillis, who alongside Shift4 Payments billionaire Jared Isaacman made the first commercial EVA during 2024's Polaris Dawn mission, to 65-year-old Mike Barratt, whose spacewalk in summer 2024 ended after 31 minutes due to a water leak. ▶

What to wear to step among the stars

From short-lived suits to wearable tech, a spacewalker's wardrobe is always changing

Since Alexei Leonov's pioneering EVA, six generations of Russia's Orlan ('sea eagle') spacesuit have seen service since 1977. The earliest Orlans could sustain a cosmonaut for three hours. Today, they routinely support EVAs lasting over seven hours.

Modern Orlans include helmet-mounted lights, rubberised fabric shoulder belts for mobility and flexion, durable gloves and autonomous radios/battery packs. Inflatable forearm cuffs enable spacewalkers to seal off punctured gloves and since 2009 Orlans carry computers that monitor suit health.

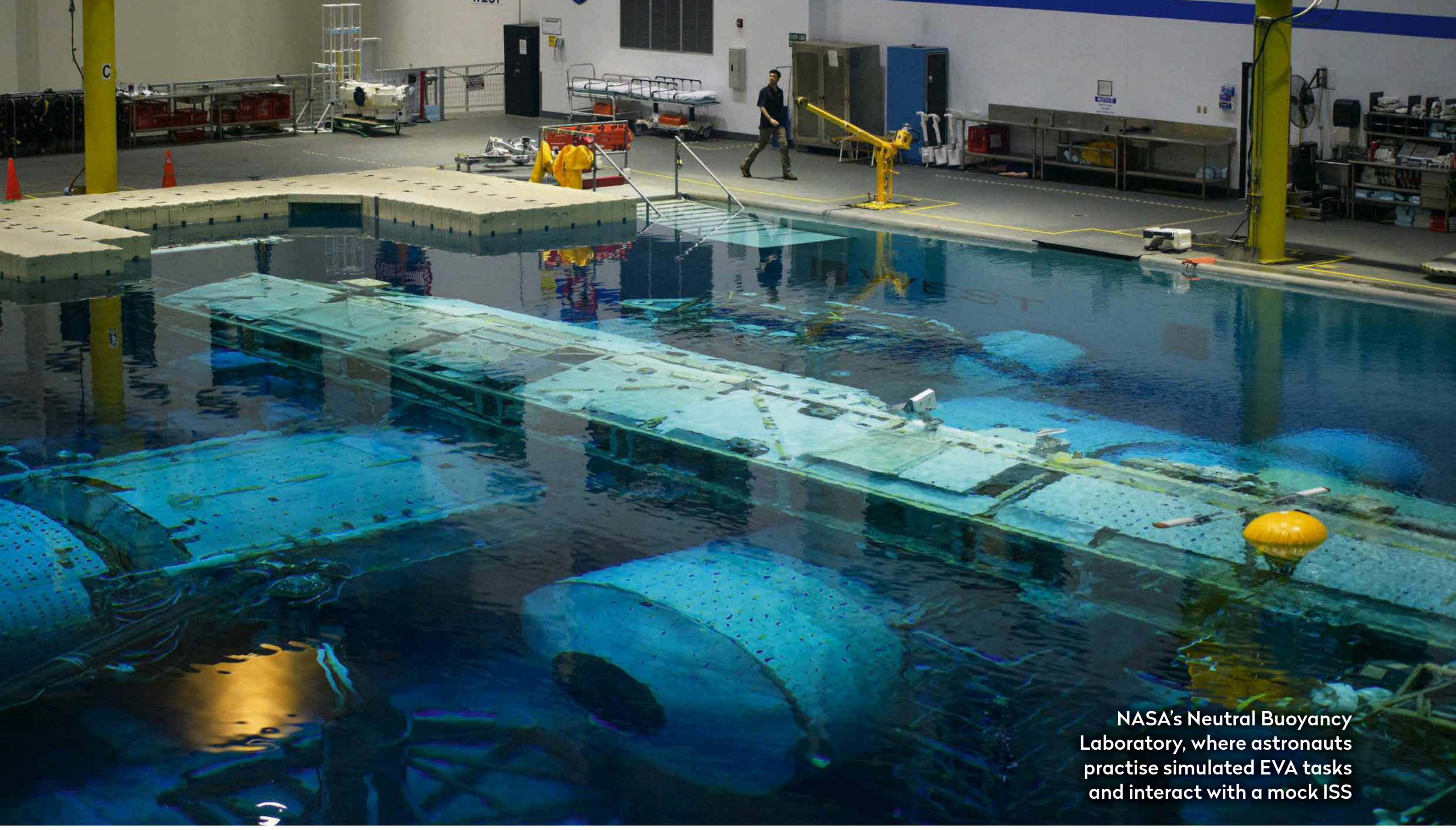
American Gemini and Apollo suits evolved convoluted joints to avoid ballooning under pressure, with greater flexibility and toughened visors. The Shuttle's Extravehicular Mobility Unit (EMU) did away with zippers in favour of a modular design with longer shelf life.

The latest Orlan suits have helmet lights and better puncture protection

Gloves with silicon rubber fingertips for tactile sensitivity, electronic cuff checklists and wireless video systems add to the EMU's versatility, which can now remain continuously in service on the ISS for years.

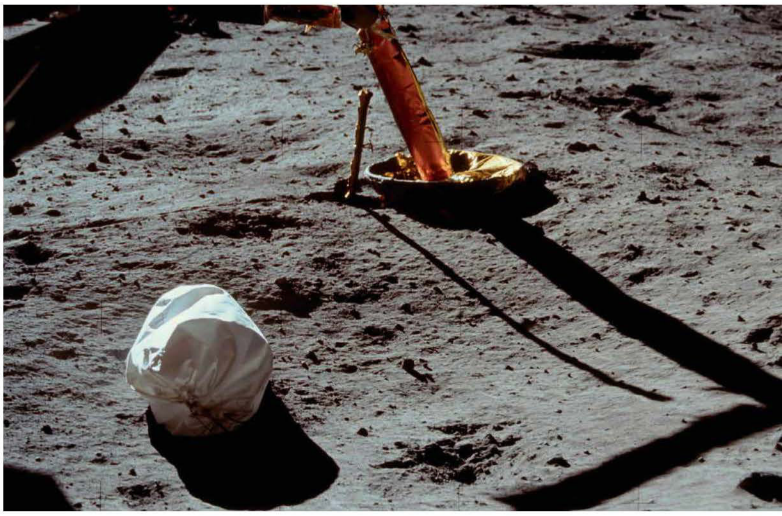
China's early Feitian suits could support spacewalkers for four hours. But last year, the newest design achieved the longest EVA in history: over nine hours.

Ahead, NASA has contracted with AxiomSpace for improved suits for its Artemis lunar missions. In 2024, China announced plans for a lightweight suit to support Moon landings, equipped with glare-proof visors, chest-mounted controls and dual helmet video cameras.



NASA's Neutral Buoyancy Laboratory, where astronauts practise simulated EVA tasks and interact with a mock ISS

NASA's Peggy Whitson holds the record for the most EVA time for a woman, clocking more than 60 hours



▲ **Even putting out the bins counts as an EVA, as Apollo lunar modules had to be depressurised just to discard bags of waste**

▶ Yevgeni Khrunov and Alexei Yeliseyev completed the first two-person EVA, a daring spaceship-to-spaceship transfer in 1969. Pierre Thuot, Rick Hieb and Tom Akers made a three-man spacewalk to salvage an Intelsat communications satellite in 1992. And Polaris Dawn saw four humans – Isaacman, Gillis, Scott Poteet and Anna Menon – all simultaneously exposed to the vacuum of space for the first time.

Russian cosmonaut Anatoli Solovyov holds records for the greatest number of spacewalks (16) and spacewalk time (78 hours and 28 minutes). USA's Peggy Whitson has the female record, with 60 hours 21 minutes over 10 EVAs.

The longest spacewalk (nine hours and six minutes) was by China's Cai Xuzhe and Song Lingdong in 2024. But the shortest is harder to quantify. Gemini astronauts opened the hatch for a few minutes to throw trash overboard. Apollo astronauts did likewise before leaving the Moon, pushing unneeded gear, waste bags and empty food cartons through the lunar module's hatch to reduce weight.

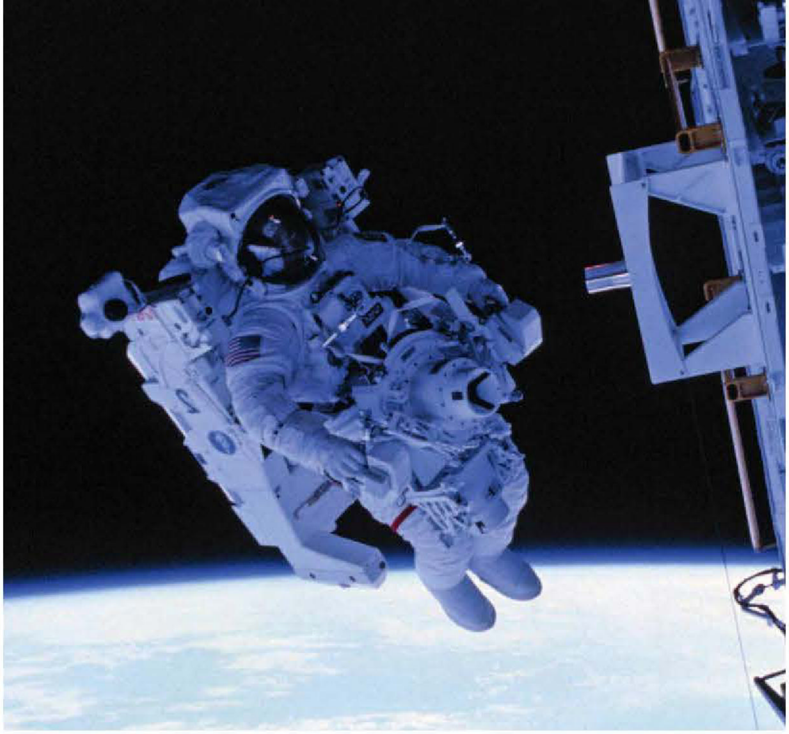
The furthest EVAs from Earth were 14 Apollo moonwalks totalling 80 hours and 26 minutes in 1969–1972. Apollo 15's Dave Scott also did a 33-minute 'stand-up' EVA from the lunar module's roof hatch to survey the Hadley–Apennine landing site. "You can move around so much more easily," said Apollo 17's Gene Cernan, one of only four men to walk in space and on the Moon. "The human being is a very unique, very adaptable creature."

During the return journey of Apollo's last three lunar voyages, astronauts made three 'deep-space' EVAs totalling three hours and seven minutes at 317,000km (197,000 miles) from Earth and 80,000km (50,000 miles) from the Moon. "The blackness defied understanding," remembered Apollo 15's Al Worden. "It stretched away from me for billions of miles."

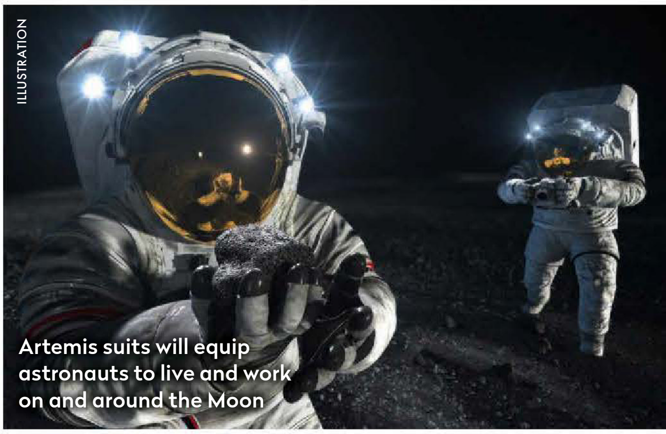
The future for EVAs

In 1984, the first untethered spacewalk saw Bruce McCandless test a jet-propelled backpack, the Manned Maneuvering Unit (MMU). It later helped

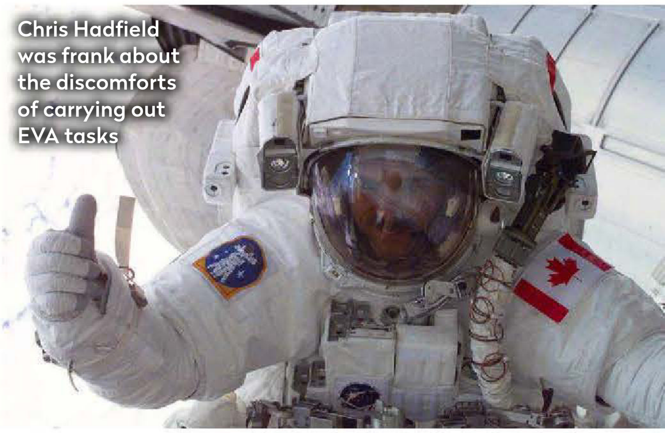
MARK FELIX/GETTY, GETTY, NASA X 6, BETTMANN/GETTY,



▲ **Untethered: Bruce McCandless using the nitrogen-propelled, hand-controlled Manned Maneuvering Unit (MMU) in 1984**



Artemis suits will equip astronauts to live and work on and around the Moon



Chris Hadfield was frank about the discomforts of carrying out EVA tasks

spacewalkers repair the Solar Max observatory and two communications satellites.

Future Artemis moonwalkers will have helmet-mounted HD cameras, advanced 4G cellular communications, sports energy gels for in-suit nutrition and augmented heads-up displays inside their visors. And eight hours of oxygen and consumables will help them explore more of the Moon than ever before.

In mid-2027, Artemis III astronauts are scheduled to spend a week on the lunar surface and do at least two moonwalks lasting six hours apiece. The Moon offers an ideal ground to prepare for future Mars missions. In 2021, NASA's Perseverance rover landed spacesuit specimens on Mars to assess their performance on the subfreezing, wind-whipped Martian surface.

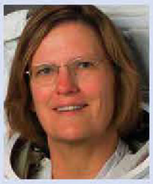
But dangers remain. "There is absolutely no margin for error when walking in space," cautioned Winston Scott, former NASA astronaut who completed three spacewalks during his career. Spacewalkers have endured bruised hands and torn fingernails, while Luca Parmitano cut short a 2013 EVA when water entered his helmet, threatening his hearing and vision. "Spacewalking," wrote Chris Hadfield, "is like rock-climbing, weightlifting, repairing a small engine and performing an intricate pas de deux, simultaneously, while encased in a bulky suit that's scraping your knuckles, fingertips and collarbone raw." Scott Kelly called EVAs "the 'type two' kind of fun: fun when it's done!".

For six decades, spacewalking has enabled humans to survive in the most lethal environment known. As we prepare to return to the Moon and head for Mars, future spacewalkers will owe a debt of thanks to Alexei Leonov, the man who made it all possible.

Ben Evans is a science writer and the author of several books on spaceflight

Tips from spacewalker Kathy Sullivan

The USA's first woman to undertake an EVA shares advice for would-be spacewalkers



"During a spacewalk, your view of Earth is not terribly different from inside the Space Station, except there's no window frame. You're pilot of the spacesuit, your very own spaceship, manoeuvring hand-over-hand. You don't have a big range of motion in your arms: your hands are usually somewhere between nose level and chin level. And that's really all you can see because the Space Shuttle or the Station is so big.

If you want to see Earth, you can't just turn your head, because your head turns inside the helmet. You have to pivot your body away from the structure you're on. It felt as much like I moved the Space Shuttle out of my way, as that I pivoted my body.

But a spacewalk is not a space stroll. You could happily just gawk forever, but you have things to do, like repairing instruments or doing science. If you ever want to do another spacewalk, you'd better do this one well.

Shortly after we left the airlock, our commander Bob Crippen told us to stop for a moment, take a look around, take it all in. That blue thing up there is Earth. You work hard for a long time to get to that point, so give yourself that moment.

My most memorable glimpse from my spacewalk was, hands above my head, I felt like I was hanging from a tree in the backyard. Except it was 200 miles down to the Earth, the blue of the Caribbean sliding between my boots."

NASA astronaut Sullivan during a repair of the Challenger Shuttle

How to see the ISS

Coming to a sky near you… It's easy to catch sight of the venerable space laboratory, once you know when to look up

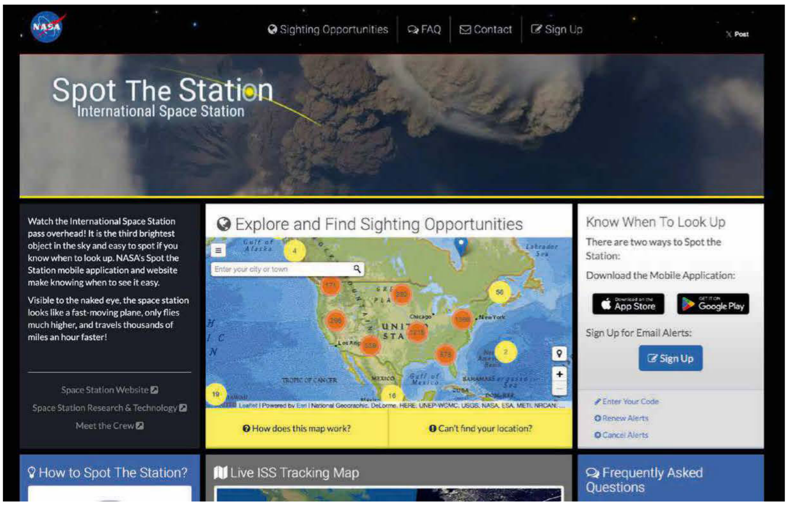
Learn how to track the International Space Station as it makes its journey across the night sky

The size of a football field, the International Space Station has been orbiting 400km (250 miles) above Earth for almost 25 years. When it passes overhead, the sunlight reflecting off its 35-metre-long (115ft) solar panels means that the station is bright enough to be seen with the naked eye, provided you know when and where to look.

The ISS's orbit takes it over the heads of around 90 per cent of the world's population, so chances are that it has already passed above you without you knowing. It circles the globe every 90 minutes, granting the crew 16 sunrises and sunsets every day, and giving viewers from Earth plenty of opportunities to catch a super-bright overhead pass.

If you want to catch a glimpse, timing is key. In the middle of the day the sky is too bright to see it, then in the middle of the night it passes into the shadow of Earth. The best sightings occur in the evening shortly after sunset, when the Sun has slipped below your horizon but there's still enough light to reflect off the station's solar panels. Early morning before sunrise is another good time.

The ISS travels at about 28,000km/h (17,500mph) and on a good clear pass it takes about six minutes to rise from one horizon, pass overhead and then disappear into Earth's shadow. There are lots of ways to work out the exact time it will be passing over your location. NASA's Spot the Station (https://spotthestation.nasa.gov) allows you to sign up for emails or text alerts for ISS passes visible from where you are. However, these might include less-than-optimal passes, such as those very low to the horizon.


NASA
Sighting Opportunities
FAQ
Contact
Sign Up
X Post
Spot The Station
International Space Station
Explore and Find Sighting Opportunities
Enter your city or town
Know When To Look Up
App Store
Google Play
Sign Up
Enter Your Code
Renew Alerts
Cancel Alerts
Space Station Website
Space Station Research & Technology
Meet the Crew
How does this map work?
Can't find your location?
How to Spot The Station?
Live ISS Tracking Map
Frequently Asked Questions

Watch the International Space Station pass overhead! It is the third brightest object in the sky and easy to spot if you know when to look up. NASA's Spot the Station mobile application and website make knowing when to see it easy.

Visible to the naked eye, the space station looks like a fast-moving plane, only flies much higher, and travels thousands of miles an hour faster!

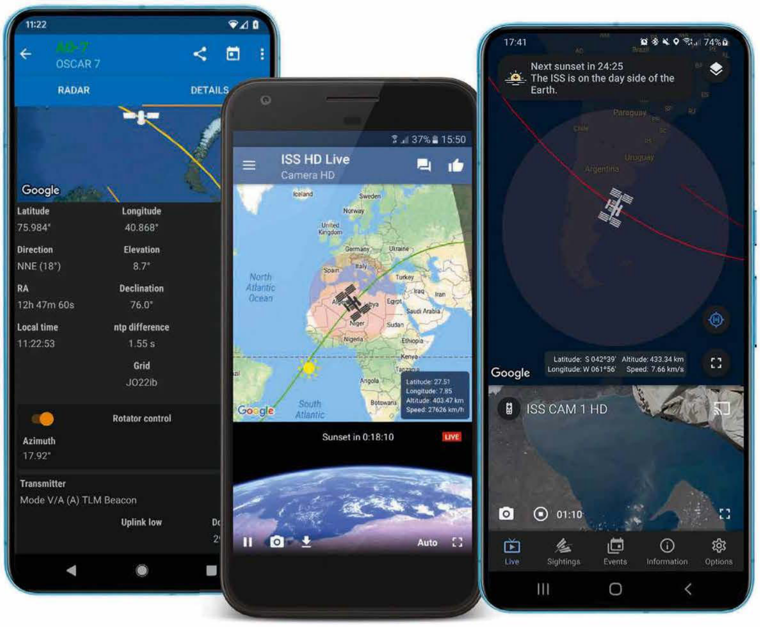
There are two ways to Spot the Station:

Download the Mobile Application:

Sign Up for Email Alerts:

▲ **Spot the Station gives ISS pass timings for over 6,700 locations worldwide and tells you exactly where to look. All passes are within hours of sunrise or sunset**

SHAUNL/GETTY, SPOTTHESTATION.NASA.GOV, ISSDETECTOR.COM, WWW.ISSLIVENOW.COM, ISSONLIVE.APP, MARCELC/GETTY



▶ **The station passes over quickly, so get ready by using a tracking app such as (left to right) ISS Detector, ISS Live Now or ISS onLive**

Meteorwatch.org, meanwhile, has a useful calendar focusing on the best high and bright ISS passes over the UK, while heavens-above.com lets you add your location before showing you the times and directions of upcoming visible passes. There are also several apps that track the ISS, including ISS Detector, Sputnik!, ISS Live Now, GoISSWatch and ISS onLive.

Pick your vantage point

Once you've found a good pass to observe (and checked it won't be clouded out), you'll want to find the best location to view the station. A pass can still wow even from a city back garden, but if you can position yourself in a spot with a wide horizon-to-horizon vista, you'll get a longer view before the ISS gets blocked by houses or trees. The ISS is very bright, typically between mag –1.0 and –4.0, making it brighter than even the brightest stars, so light pollution shouldn't be a problem.

Passes always start from a westerly direction, so you'll want to look that way. Look out for a bright white light travelling silently and smoothly across the sky. If you see flashing lights, you're looking at an aircraft, not the ISS; the ISS has no visible flashing lights whatsoever. If you have a pair of binoculars, then you can get a closer look by fixing your eyes on the light of the station and lifting your binoculars into position to view the same spot. You won't be able to make out the shape of the station, but it will make it appear brighter. The station moves so fast it quickly passes through the field of view of a telescope, meaning you can leave the scope behind (unless you're planning on taking a photo – see page 74).

Once you've caught the station, all you need do is sit back and enjoy the pass, perhaps offering a wave to the astronauts travelling overhead.

Jess Wilder is the senior production editor of *BBC Sky at Night Magazine*

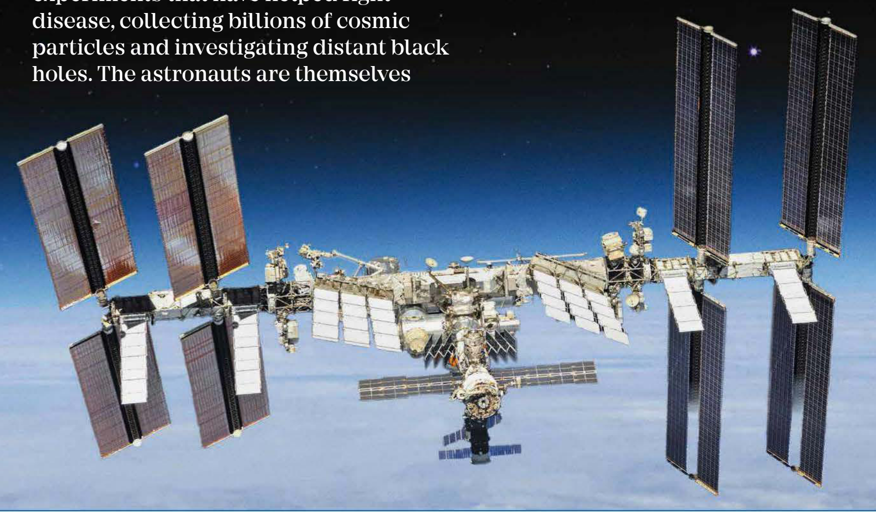
How the station got there

It took 12 years to put the massive space laboratory together

Though both Russia and NASA launched and operated their own small, short-term space stations throughout the 1980s, both nations wanted to create a more permanent space base. However, it soon became clear that the cost and complexity of such an endeavour were beyond the means of a single agency. In 1993, the pair announced they were joining forces along with the European, Japanese and Canadian space agencies to create what would become the International Space Station.

The station was built from several modules, each launched individually, with the first arriving in orbit in 1998. By the time the ISS was fully assembled in February 2011, the station measured 109 metres (358ft) long and weighed in at 450,000kg (990,000lb). The ISS hadn't been sitting vacant, however, with the first crew arriving on 2 November 2000. There has been a human presence on the station ever since. Typically, the ISS has seven astronauts living on board, but has housed as many as 13 people at one time.

While on the ISS, the astronauts act as scientific researchers, conducting experiments that have helped fight disease, collecting billions of cosmic particles and investigating distant black holes. The astronauts are themselves experiments, constantly monitoring their own vitals to understand how the human body reacts to an extended time in microgravity. Along with lessons learned from operating the station itself, this research is helping to shape current plans for longer space missions further afield, including to the Moon and even Mars.



Made of 16 pressurised modules, the ISS took over 40 US and Russian missions to build piece by piece

R910X RECYCLED HOODED PADDED PARKA

SUPREME BODY WARMTH IN LIGHTWEIGHT RECYCLED FABRICS

recycled by Result

shop.resultclothing.com

Increase the efficiency of your reflector by up to 25%

Our **HI-LUX coating** can be applied to almost **any** reflector, in virtually any condition or no matter how old. Improves the reflective efficiency of your mirrors.

HI-LUX High Reflectivity Coating

Find out more on our website: Optics > Mirror Recoating or call / email

ORION optics UK

tech enquiries: john@orionoptics.co.uk

Telephone 01782 614200

www.orionoptics.co.uk

recycle

The Possibilities are Endless

The New York Ti

Recycle your magazine and seven days
later it could come back as your newspaper

www.recyclenow.com

British Astronomical Association

Deep Sky Section Annual Meeting 2025

Nebulae!

22nd March 2025
10:00- 17:00

In the shadow of Jodrell Bank

Goostrey Village Hall, Goostrey,
Cheshire, CW4 8PE.
Hosted by
Macclesfield Astronomical Society

All welcome

BAA

For full details and to book
tickets visit the BAA website
https:/britastro.org/events

DON'T JUST READ *BBC COUNTRYFILE MAGAZINE*... LISTEN TO IT, TOO

Your chance for a weekly adventure in nature and the countryside with the *BBC Countryfile Magazine* team

BBC COUNTRYFILE MAGAZINE
The Plodcast

You can find the Plodcast on all good podcast platforms

16-PAGE CENTRE PULLOUT

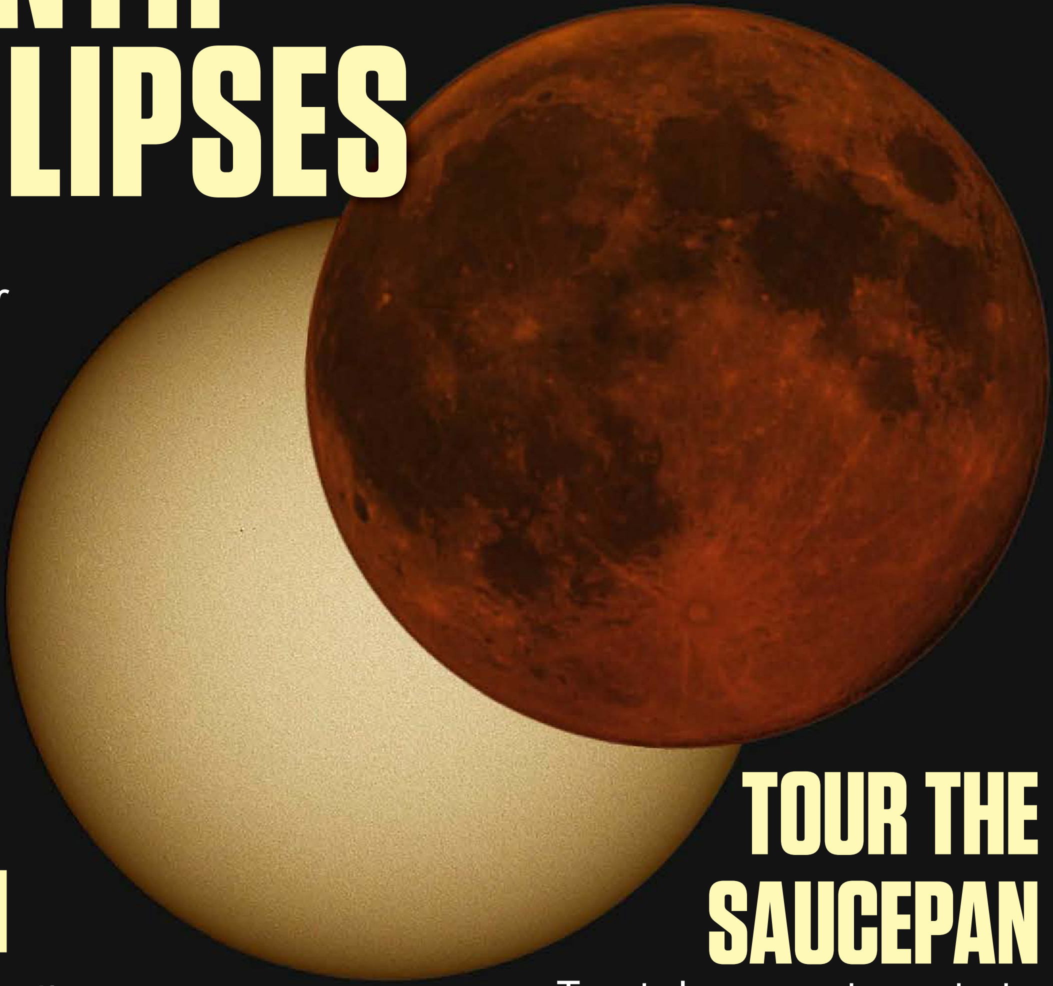
BBC Sky at Night MAGAZINE

The Sky Guide

MARCH 2025

A MONTH OF ECLIPSES

March 2025 has both a total lunar eclipse and a partial solar eclipse on offer



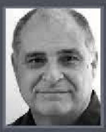
VENUS SUN DASH

The Evening Star dives towards solar conjunction

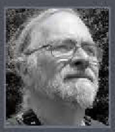
TOUR THE SAUCEPAN

Top telescope targets to spot in the iconic asterism

About the writers



Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four



Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month…

- ✦ Large minor planet Flora at opposition
- ✦ Orange giant Alphard, the solitary one
- ✦ Explore binocular sights in Auriga–Gemini

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

MARCH HIGHLIGHTS

Your guide to the night sky this month

◀ Saturday

1 This evening and tomorrow evening, the waxing crescent Moon sits near Venus, a gorgeous sight given clear skies after sunset.

Tuesday

4 A double shadow transit event can be seen on Jupiter between 23:36 UT tonight and 02:12 UT on 5 March. The shadows involved are those of Ganymede and Europa.

Sunday ▶

9 In the early hours, Mars will appear very close to the 74%-lit waxing gibbous Moon. At 01:48 UT, mag. –0.1 Mars is 55 arcseconds south of the Moon's centre as seen from the centre of the UK.

Wednesday

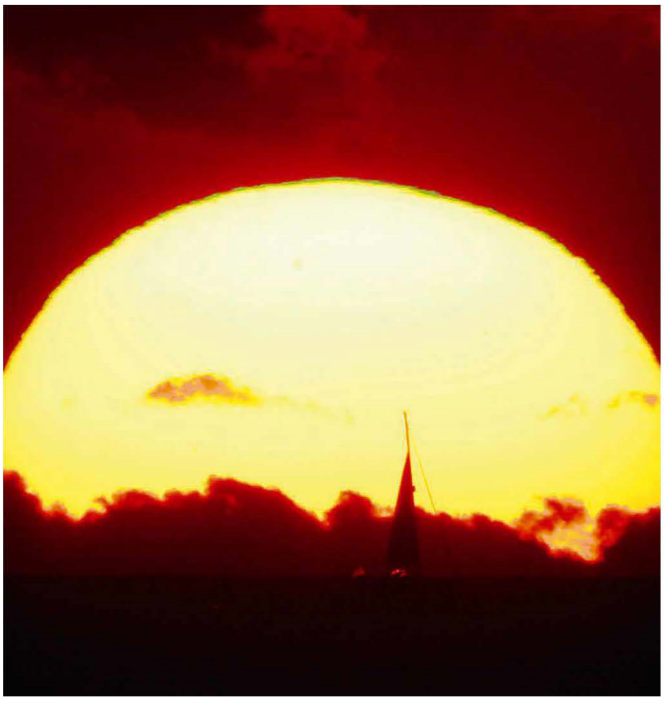
12 Minor planet 8 Flora reaches opposition. Turn to page 53 for further details.

Thursday

13 Mag. –4.2 Venus and mag. +1.0 Mercury appear separated by 5.6°, visible low above the western horizon shortly after sunset this evening.

◀ Friday

14 A total lunar eclipse occurs this morning, starting at 03:57 UT and ending after the Moon sets. Totality occurs just before moonset.



◀ Thursday

20 The centre of the Sun crosses the celestial equator at 09:01 UT, marking the Northern Hemisphere's vernal or spring equinox. For those in the Southern Hemisphere, the instant marks their autumn equinox.

Sunday

23 Venus reaches inferior conjunction today, passing just 8.4° from the centre of the Sun's disc Turn to page 55 for details of how to see this safely.

Saturday ▶

29 A partial eclipse of the Sun is visible from around 10:00 UT this morning. Turn to page 46 to find out how to observe it safely.

PETE LAWRENCE X 7

Wednesday

5 Jupiter's moon Callisto sits 1 arcsecond north of the planet's northern limb at 19:57 UT.

Venus is now showing a phase of 10% and appears 52 arcseconds across.

Thursday

6 In the early hours, the 42%-lit waxing crescent Moon is near bright Jupiter as both objects approach the northwest horizon. Then later in the day, as the sky darkens after sunset, the first quarter Moon can be seen still close to Jupiter.

Saturday

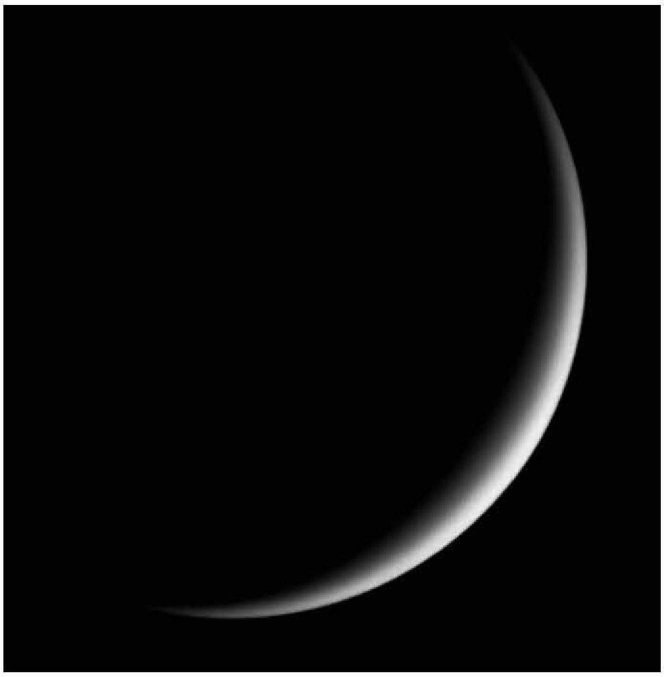
8 Mercury reaches greatest eastern elongation, 18.2° from the Sun in the evening sky.

A view of the 70%-lit waxing gibbous Moon at 14:00 UT will show the clair-obscur effect known as the Jewelled Handle.

Tuesday ▶

11 Venus now has a phase of 5%, its beautiful crescent appearing 56 arcseconds across.

Ganymede transits Jupiter's disc between 21:25 and 23:58 UT.



Tuesday

18 Now is a good time to start looking at this month's Moonwatch target (see page 52), Vallis Capella.

◀ Monday

24 Lunar libration currently favours features in the southwest part of the Moon, an area that includes the impressive albeit heavily foreshortened Mare Orientale, the Eastern Sea.

Tuesday

25 This month's Deep-Sky Tour on page 56 is looking at objects near to the Owl Nebula, M97 in Ursa Major. The Moon is out of the way currently, leaving the sky good and dark to take the tour.

Sunday

30 Daylight savings comes into effect from 01:00 UT this morning, when the clocks advance one hour to become 02:00 BST.

Family stargazing

The solar eclipse on 29 March is conveniently timed for observation. It's imperative that solar safety procedures are used, especially with youngsters. One safe way to observe the event is to create a simple pinhole camera and project the Sun's light onto a piece of white card used as a screen. Take another card and make a circular 1–2mm hole in its centre. Hold this up a reasonable distance from the screen. The bright point of light on the screen will be a small image of the Sun and will show the progression of the eclipse quite well. **www.bbc.co.uk/cbeebies/shows/stargazing**

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

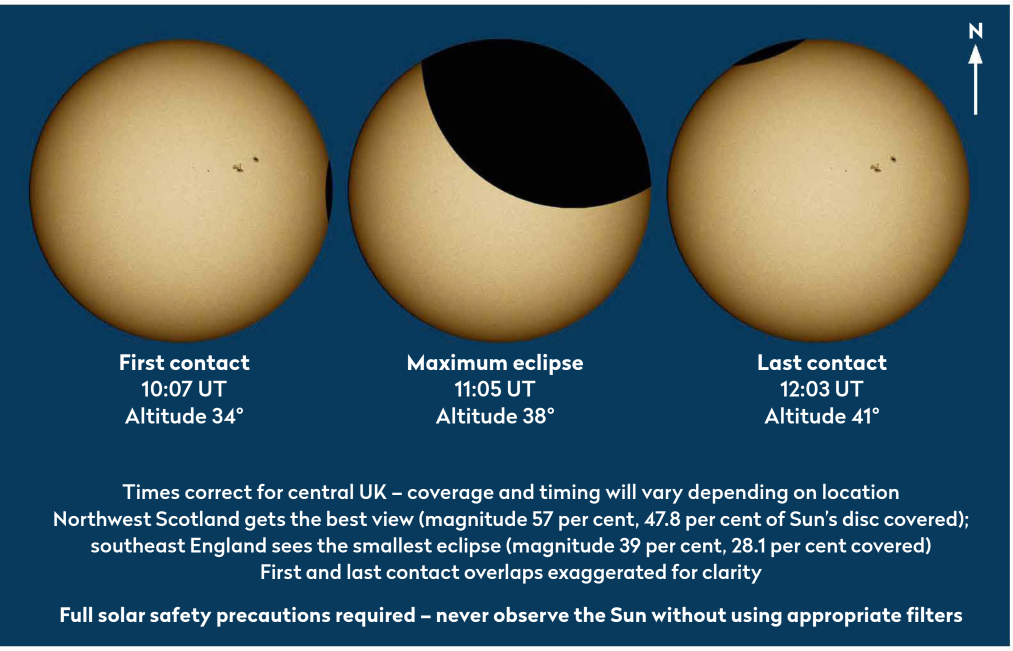
GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **bit.ly/stargazing-top-tips** to learn how to stargaze in 12 easy steps and **bit.ly/choose-first-telescope** for advice on choosing your first scope

DON'T MISS

Partial solar eclipse

BEST TIME TO SEE: 29 March, 10:00–12:15 UT



Times correct for central UK – coverage and timing will vary depending on location
Northwest Scotland gets the best view (magnitude 57 per cent, 47.8 per cent of Sun's disc covered);
southeast England sees the smallest eclipse (magnitude 39 per cent, 28.1 per cent covered)
First and last contact overlaps exaggerated for clarity

Full solar safety precautions required – never observe the Sun without using appropriate filters

▲ What will happen and when during the partial solar eclipse on 29 March

CAUTION
Don't look at the Sun directly with the naked eye or any unfiltered optical instruments

There are two eclipses taking place this month, one well placed for UK viewing, the other not so optimal, setting just as the eclipse gets going. The better-positioned eclipse is on 29 March, when the Moon will pass across the disc of the Sun to cause a partial solar eclipse. Although it doesn't match a total solar eclipse, a partial eclipse of the Sun is still amazing to observe and there are many ways to do this safely.

The event begins with first contact at 10:07 UT (time for the centre of the UK; timings vary by location), when the Moon's leading edge first makes contact with the edge of the Sun. After this, an ever-increasing bite appears to be taken out of the Sun's disc until the point of greatest eclipse at 11:05 UT. The eclipse appears to have the greatest coverage from the northwest of Scotland where 47.8 per cent of the Sun's disc will be covered by the Moon. The southeast of England gets the smallest eclipse, with only 28.1 per cent of the Sun's area hidden by the Moon.

The whole of the eclipse occurs at an altitude over 34°, making it well placed for UK viewing. If you plan to view or image the event through a telescope, you need to take full solar precautions and a full-aperture certified solar safety filter is advised. Another safe method for observing the eclipse is to use a piece of white card as a screen and another piece of card for projection. A 1–2mm hole created in the projection card allows the Sun's light to pass through, projecting a pinhole image onto the screen card. The projected image is a small but perfectly formed representation of the eclipse.

For those with hydrogen-alpha solar viewing kit (note, not hydrogen-alpha deep-sky filters, which are not suitable), the eclipse progress is given an interesting boost as there are many more light and dark features visible within the Sun's chromosphere to use as a gauge for how the Moon is progressing. In addition, seeing the sharp profile of the Moon's edge cutting across any visible prominences is a stirring sight.

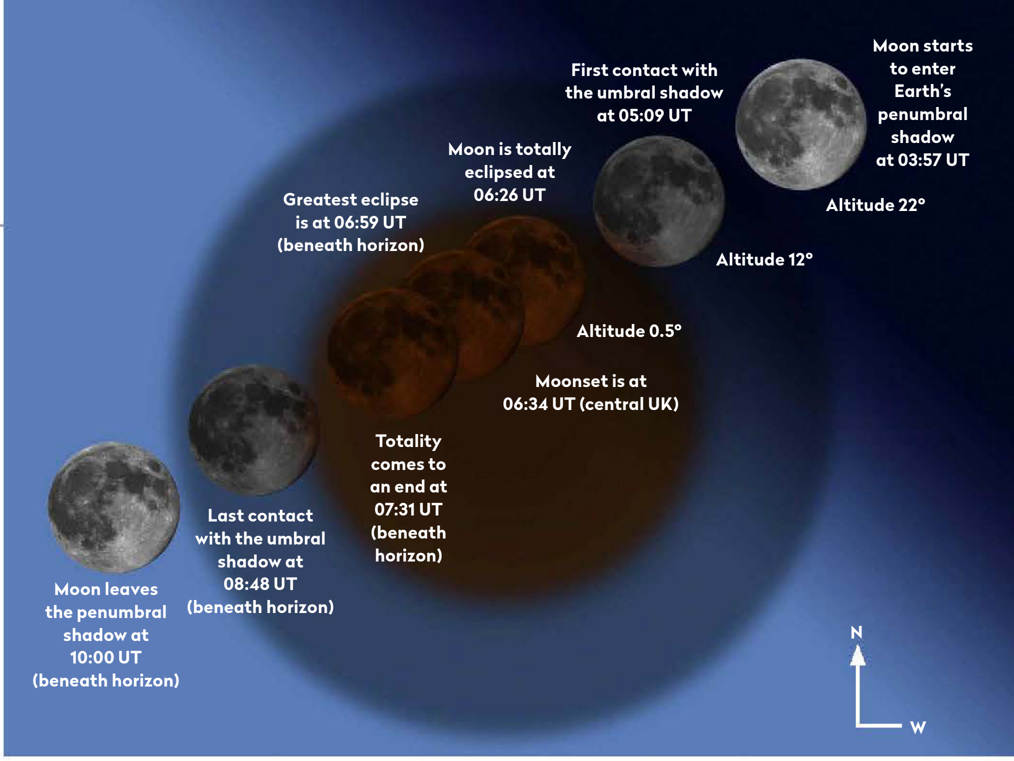
The current solar cycle is expected to peak in 2025, making it highly likely that the Sun's disc will have lots of interest on it whether in hydrogen-alpha, another narrowband wavelength or white light. Sunspots or equivalent features provide a useful backdrop that allows you to visualise the Moon's motion in its orbit.

▲ Holes in a piece of card creating multiple pinhole images of a partial solar eclipse

ALL PICTURES: PETE LAWRENCE

Total lunar eclipse

BEST TIME TO SEE: 14 March from 03:30 UT until moonset around 06:30 UT


Moon starts to enter Earth's penumbral shadow at 03:57 UT
Altitude 22°
First contact with the umbral shadow at 05:09 UT
Altitude 12°
Moon is totally eclipsed at 06:26 UT
Altitude 0.5°
Moonset is at 06:34 UT (central UK)
Greatest eclipse is at 06:59 UT (beneath horizon)
Totality comes to an end at 07:31 UT (beneath horizon)
Last contact with the umbral shadow at 08:48 UT (beneath horizon)
Moon leaves the penumbral shadow at 10:00 UT (beneath horizon)
N
W

▲ The total lunar eclipse on 14 March sets just after totality is reached

Before the partial solar eclipse on 29 March, there's a less favourably timed eclipse to look out for on 14 March. This one is a lunar eclipse, when the Moon passes into Earth's shadow in space. The 14 March event will be a total lunar eclipse, the Moon completely immersing itself into the darkest part of Earth's shadow, known as the umbral shadow.

The eclipse begins at 03:57 UT when the Moon first encounters the light, outer portion of Earth's shadow known as the penumbral shadow. This is a very weak affair and the initial passage of the Moon into it will be hardly noticeable at all.

Later, as the dawn twilight brightens, the western portion of the Moon will look more shaded, maximally just before the Moon first encounters the umbral shadow at 05:09 UT. The passage of the Moon into this darker shadow will be obvious, but it'll be battling the bright dawn sky, the Moon's altitude just 12° at this time.

It takes the Moon 1 hour and 17 minutes to fully immerse into the umbral shadow, reaching totality at 06:26 UT. However, this is achieved just moments before moonset and low altitude will mean it'll be hard to see well. The combination of darkening lunar surface and brightening twilight in the lead-up to totality may well make the darker portion of the Moon disappear from view, leaving just the oddly shaped part of the surface not yet immersed in Earth's umbral shadow.

Later in 2025, on 7 September, there's a second total lunar eclipse; this will be the opposite of this event, the Moon rising while totally eclipsed, giving the UK a view of the second half of the eclipse.

Venus at inferior conjunction

BEST TIME TO SEE: 23 March, 05:30–18:40 UT

Venus reaches inferior conjunction on 23 March, the planet experiencing the same ecliptic longitude as the Sun. Lined up with the Sun in the sky, at inferior conjunction Venus is also closest to Earth.

Like the Moon, Venus shows phases and over recent weeks has appeared as a shrinking crescent through the eyepiece. All the while, its apparent diameter has been expanding, reaching around 1 arcsecond across at inferior conjunction. At this time, Venus will be at its slimmest phase. Unlike the airless Moon, which essentially disappears when new, Venus's atmosphere can illuminate all the way around to form what's known as an atmospheric ring.

Unfortunately, this won't be seen this time around as this inferior conjunction takes Venus too wide of the Sun's centre, at 8.4° separation. With care and attention to safety, it is possible to locate and image Venus in this position, but it's not safe to look at it through the eyepiece of a telescope.

This should only be attempted if you know what you're doing and have experience with finding Venus close to the Sun. If not, instead try to follow Venus after sunset for as long as you can, switching to trying to locate it in the morning sky before sunrise, once it has passed inferior conjunction. Turn to page 55 for further details.

▲ Venus at inferior conjunction appears as a very thin crescent

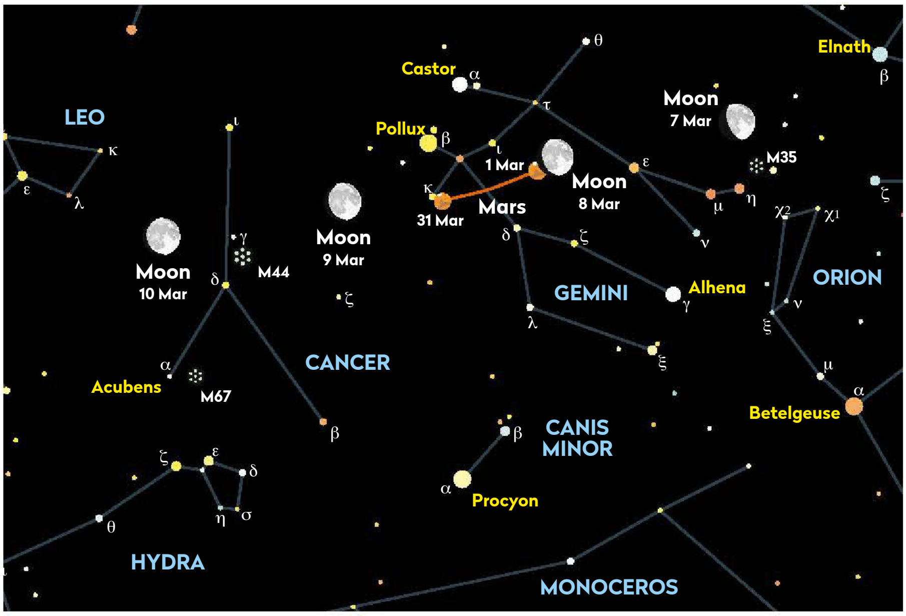
THE PLANETS

Our celestial neighbourhood in March

PICK OF THE MONTH

Mars

Best time to see: 1 March, 20:50 UT
Altitude: 63°
Location: Gemini
Direction: South
Features: Polar caps, surface markings, weather
Recommended equipment: 75mm scope or larger


LEO
κ
ε
λ
Moon
10 Mar
δ
γ
M44
Moon
9 Mar
ζ
ι
Castor
α
Pollux
β
θ
τ
ι
1 Mar
κ
31 Mar
Mars
Moon
8 Mar
δ
ζ
Moon
7 Mar
M35
Elnath
β
ε
μ
η
ν
χ2
χ1
ζ
GEMINI
Alhena
γ
ORION
ν
ξ
λ
ξ
CANCER
α
Acubens
M67
β
μ
α
Betelgeuse
β
CANIS
MINOR
ζ
ε
δ
η
σ
θ
α
Procyon
HYDRA
MONOCEROS

▲ Mars's position this month: still an enticing sight post-opposition, but shrinking rapidly

Mars is a wonderful planet to observe through a telescope but it's also one that requires effort and timing. Its apparent size varies depending on how close it is to Earth. The best time to observe the planet is around opposition, which last happened on 16 January 2025. In the weeks that follow opposition, our view of the Red Planet changes quickly, its apparent size shrinking rapidly as it once again distances itself from Earth.

On 1 March, Mars is able to reach a peak altitude of 63° in the early evening under dark-sky conditions. Through the eyepiece, the planet appears to have an apparent diameter of 10 arcseconds and is visually bright at mag. –0.3.

On 9 March around 01:40 UT, Mars appears 56 arcminutes south of the centre of the 74%-lit waxing gibbous Moon. By mid-month, the planet only just reaches its highest point when due south under conditions of darkness. By the end of March, the expansion of the evening twilight begins to affect this situation, with Mars appearing 59° up in darkening twilight around 20:10 UT. On 31 March, Mars will have dimmed to mag. +0.4 and shrunk through the eyepiece with an apparent diameter of 8 arcseconds.

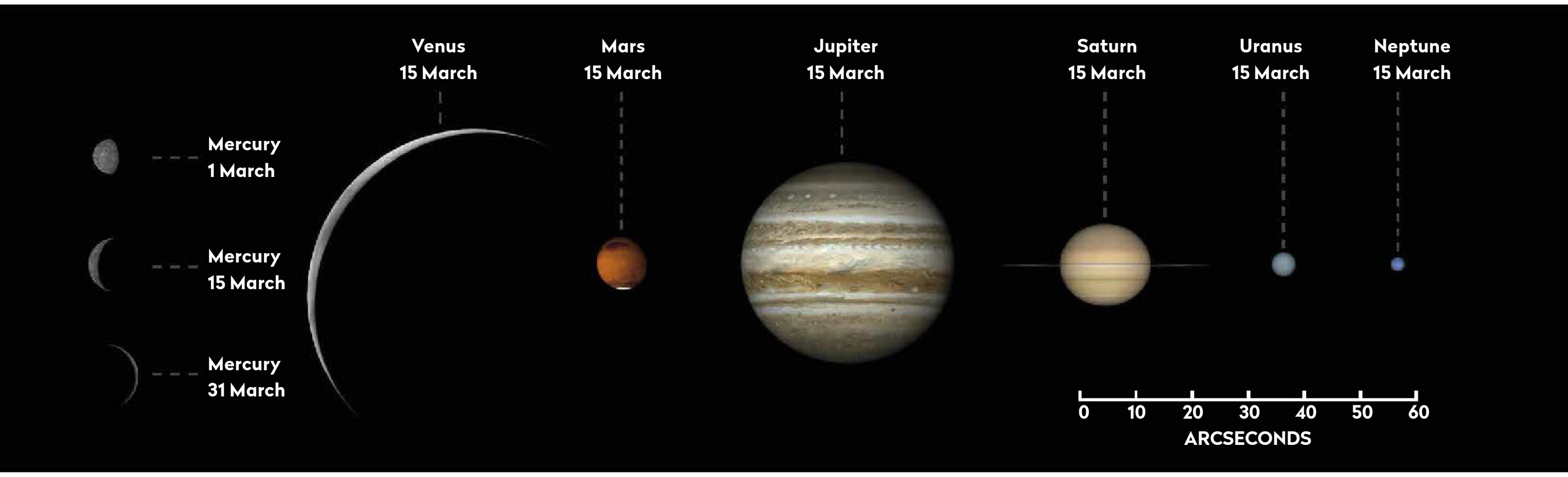
▲ The famous V-shaped Syrtis Major will be on view early evening in late March

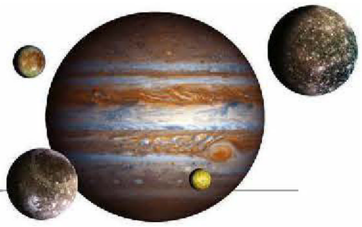
To get the best from Mars through a telescope, it's important to let your eye get used to the view. What might at first look like an uninteresting pink blob can actually hold much subtle detail. On a clear night with stable seeing, allow yourself plenty of time to fixate on obvious features, such as the northern polar cap. Then, as your eyes relax, tantalising details will begin to reveal themselves.

PETE LAWRENCE X 2

The planets in March

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope


Venus
15 March
Mars
15 March
Jupiter
15 March
Saturn
15 March
Uranus
15 March
Neptune
15 March
Mercury
1 March
Mercury
15 March
Mercury
31 March
0
10
20
30
40
50
60
ARCSECONDS



Mercury

Best time to see: 8 March, from 30 minutes after sunset
Altitude: 11°
Location: Pisces
Direction: West

Mercury is an evening planet at the start of March, setting 1.5 hours after the Sun on 1 March when it shines at mag. –0.9. A 3%-lit waxing crescent Moon sits 7.3° to the east-northeast of Mercury on this date, both objects visible in the darkening evening twilight sky after sunset. On 2 March, Mercury sits just 1.9° from mag. +7.9 Neptune, with twilight causing major problems with the visibility of this distant ice giant.

Mercury reaches greatest eastern elongation on 8 March when it appears separated from the Sun by 18.2°. On 12 March, now shining at mag. +0.7, Mercury sits 5.6° from mag. –4.2 Venus. From the middle of the month, Mercury's visibility becomes poor as it approaches inferior conjunction on 24 March. It's not visible as it re-emerges into the morning sky at the end of the month.

Venus

Best time to see: 1 March, 1 hour after sunset
Altitude: 19°
Location: Pisces
Direction: West

Evening planet Venus makes a rapid dash towards the Sun this month, to reach inferior conjunction on 23 March. On 1 March, shining at mag. –4.2, Venus sets a little over 3 hours after the Sun. On 2 March, a 10%-lit waxing crescent Moon sits 10.2° to the east of the planet. Venus and Mercury are in conjunction on 12 March, with Venus lost from naked-eye visibility soon after this. During inferior conjunction, those familiar with safe viewing close to the Sun may catch a glimpse of the planet (see page 47). At the end of March, Venus rises an hour before the Sun.

Jupiter

Best time to see: 1 March, 19:00 UT
Altitude: 58°
Location: Taurus
Direction: West of south

Jupiter's observing window begins to close this month, the planet visible at a peak altitude of 58° under deep twilight when it's just to the west of south on 1 March. Jupiter is visited by a 41%-lit waxing crescent Moon on 5 March, the Moon 8.4° northwest of the planet at 23:30 UT. By the end of March, Jupiter is at 40° altitude at 20:00 UT under dark twilight conditions.

Saturn

Not visible this month. Solar conjunction on 12 March. Ring plane crossing on 23 March.

Uranus

Best time to see: 1 March, 19:00 UT
Altitude: 58°
Location: Taurus
Direction: West of south

Located 19° west of Jupiter, Uranus's observing window closes a little earlier than the gas giant. At mag. +5.8 you'll need dark conditions to see Uranus, achieved on 1 March at 19:40 UT when the planet is 44° up. By 31 March, Uranus is just 18° up at 20:45 UT under similar conditions.

Neptune

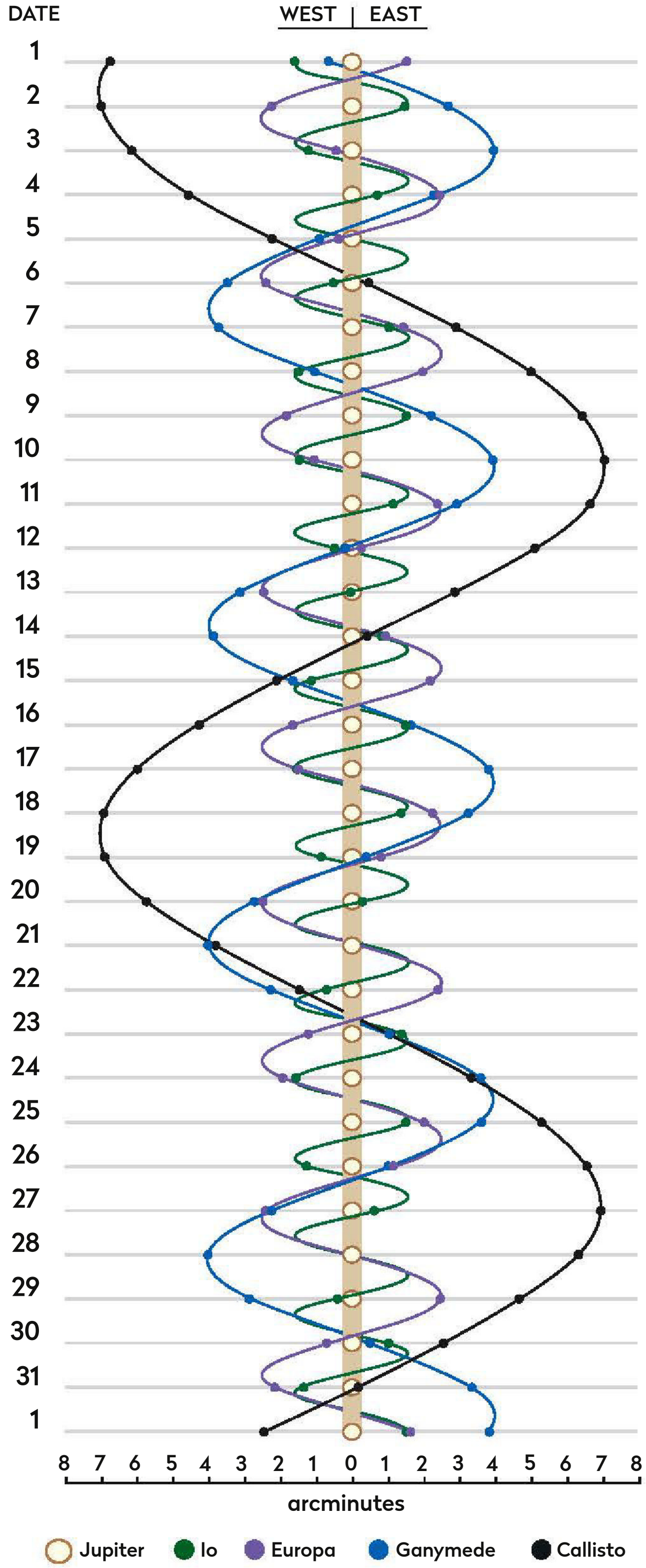
Not visible this month.

FREE BONUS CONTENT

Print planet observing forms www.skyatnightmagazine.com/bonus-content

JUPITER'S MOONS: MARCH

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 00:00 UT.



THE NIGHT SKY – MARCH

Explore the celestial sphere with our Northern Hemisphere all-sky chart

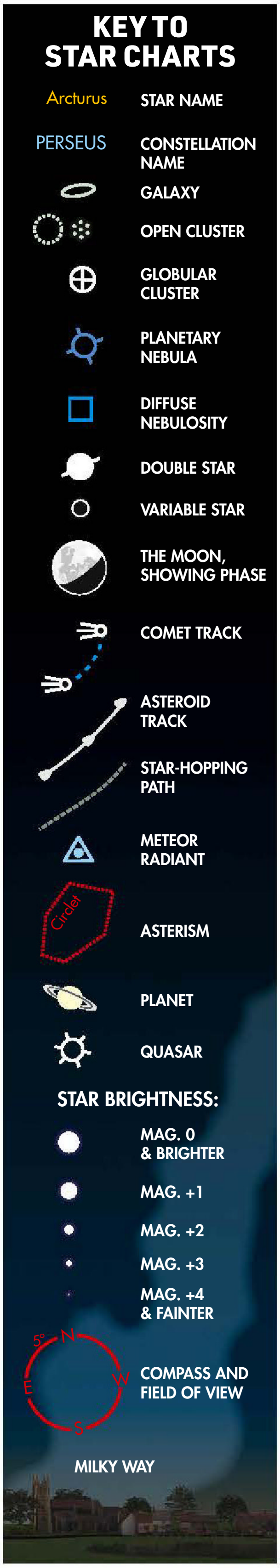

KEY TO STAR CHARTS
Arcturus
STAR NAME
PERSEUS
CONSTELLATION NAME
GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
THE MOON, SHOWING PHASE
COMET TRACK
ASTEROID TRACK
STAR-HOPPING PATH
METEOR RADIANT
Circlet
ASTERISM
PLANET
QUASAR
STAR BRIGHTNESS:
MAG. 0 & BRIGHTER
MAG. +1
MAG. +2
MAG. +3
MAG. +4 & FAINTER
5°
N
E
W
S
COMPASS AND FIELD OF VIEW
MILKY WAY

CHART: PETE LAWRENCE

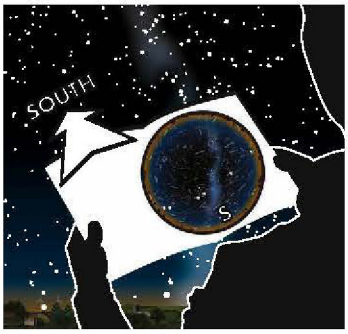
When to use this chart

1 March at 00:00 UT
15 March at 23:00 UT
31 March at 23:00 BST

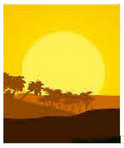
On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in March*



Date	Sunrise	Sunset
1 Mar 2025	06:57 UT	17:48 UT
11 Mar 2025	06:33 UT	18:07 UT
21 Mar 2025	06:09 UT	18:25 UT
31 Mar 2025	06:45 BST	19:43 BST

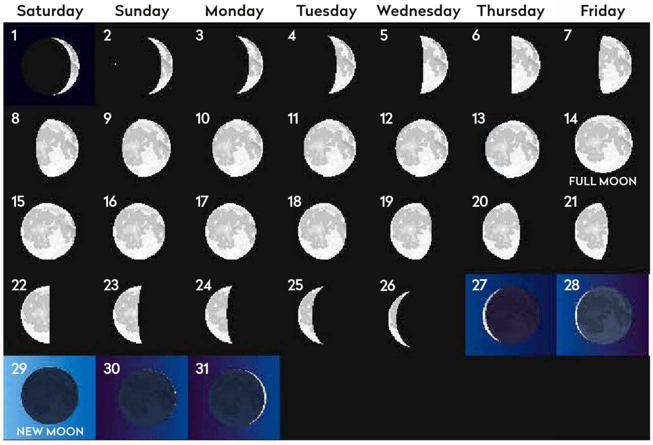
Moonrise in March*

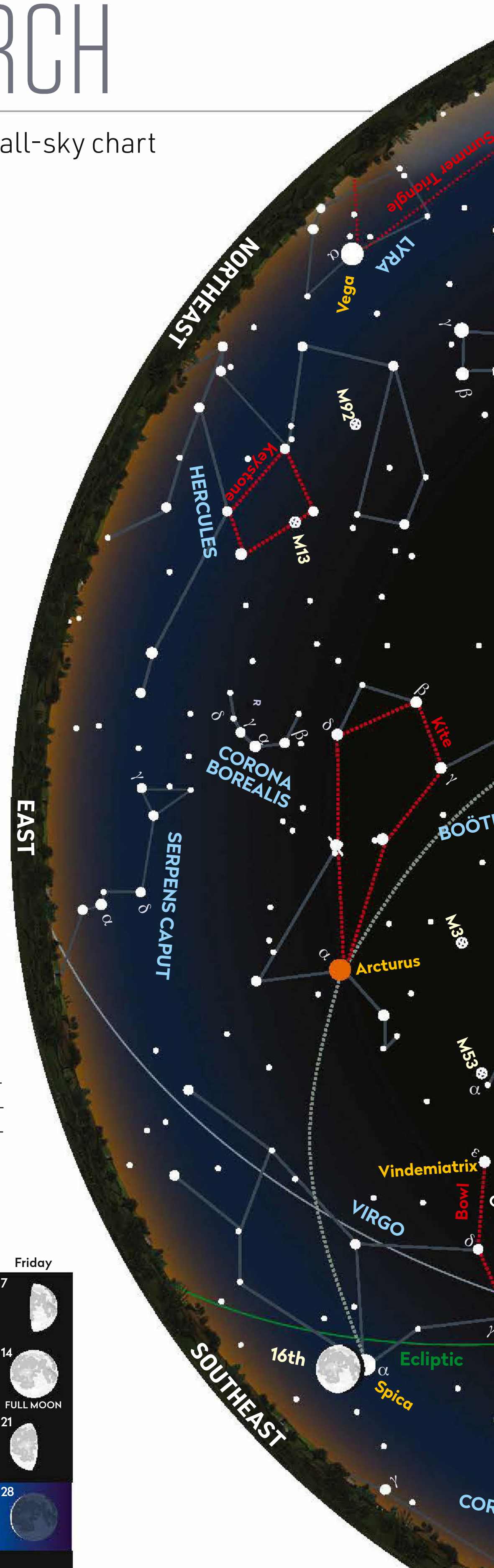
Moonrise times

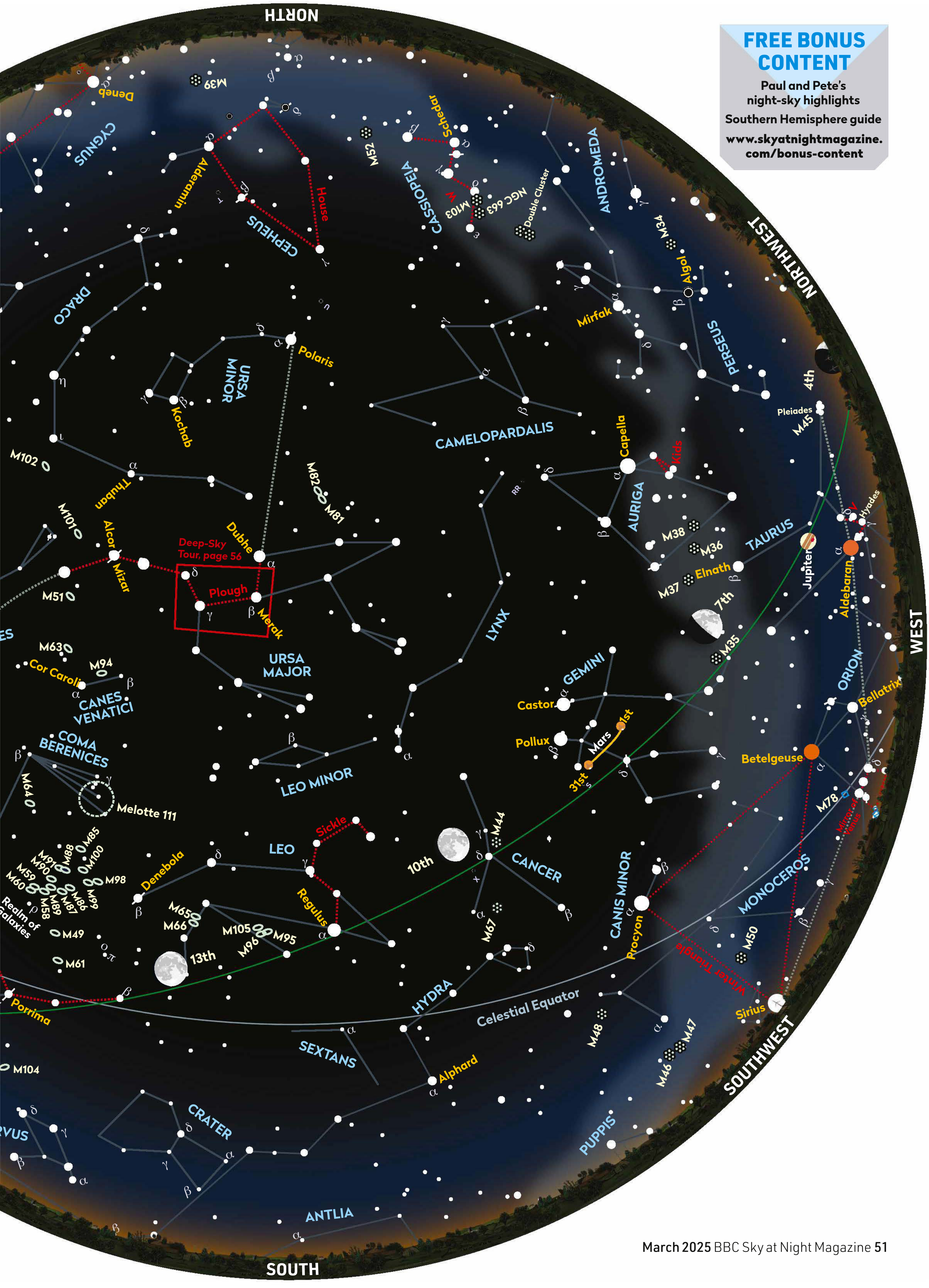
1 Mar 2025, 07:31 UT
5 Mar 2025, 08:26 UT
9 Mar 2025, 12:05 UT
13 Mar 2025, 17:26 UT
17 Mar 2025, 22:21 UT
21 Mar 2025, 02:08 UT
25 Mar 2025, 04:58 UT
29 Mar 2025, 05:47 UT

*Times correct for the centre of the UK

Lunar phases in March




NORTHEAST
Summer Triangle
LYRA
Vega
α
γ
β
M92
HERCULES
Keystone
M13
CORONA BOREALIS
R
δ
γ
β
δ
β
Kite
γ
BOÖT
EAST
SERPENS CAPUT
γ
α
δ
α
Arcturus
M3
M53
α
Vindemiatrix
ε
VIRGO
Bowl
δ
γ
16th
Ecliptic
α
Spica
SOUTHEAST
γ
COR


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
Deneb
M39
CYGNUS
Alderamin
CEPHEUS
House
M52
CASSIOPEIA
Schedar
W
M103
NGC 663
Double Cluster
ANDROMEDA
M34
Algol
PERSEUS
Mirfak
4th
Pleiades
M45
DRACO
Polaris
URSA MINOR
Kochab
CAMELOPARDALIS
Capella
Kids
AURIGA
M102
Thuban
M82
M81
RR
M101
Alcor
Mizar
Dubhe
Deep-Sky Tour, page 56
Plough
Merak
M51
URSA MAJOR
LYNX
M38
M36
M37
Elnath
7th
TAURUS
Jupiter
Aldebaran
Hyades
M35
ORION
Bellatrix
M63
Cor Caroli
M94
CANES VENATICI
COMA BERENICES
M64
Melotte 111
GEMINI
Castor
Pollux
Mars
31st
1st
Betelgeuse
M78
Mira
Venus
LEO MINOR
LEO
Sickle
10th
M44
CANCER
CANIS MINOR
Procyon
MONOCEROS
M50
Winter Triangle
Sirius
Denebola
Regulus
M85
M88
M100
M91
M90
M98
M59
M60
M89
M58
M87
M86
M99
Realm of Galaxies
M49
M65
M66
M105
M95
M96
M61
13th
M67
HYDRA
Celestial Equator
Porrima
M48
M47
M46
SEXTANS
Alphard
M104
CRATER
CORVUS
PUPPIS
ANTLIA

FREE BONUS CONTENT

Paul and Pete's night-sky highlights

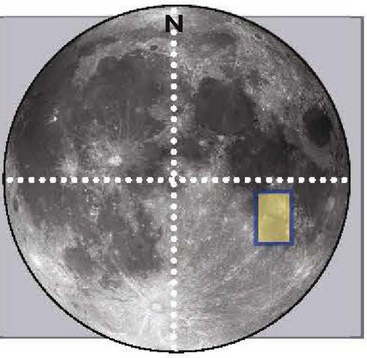
Southern Hemisphere guide

www.skyatnightmagazine.com/bonus-content

MOONWATCH March's top lunar feature to observe

Vallis Capella

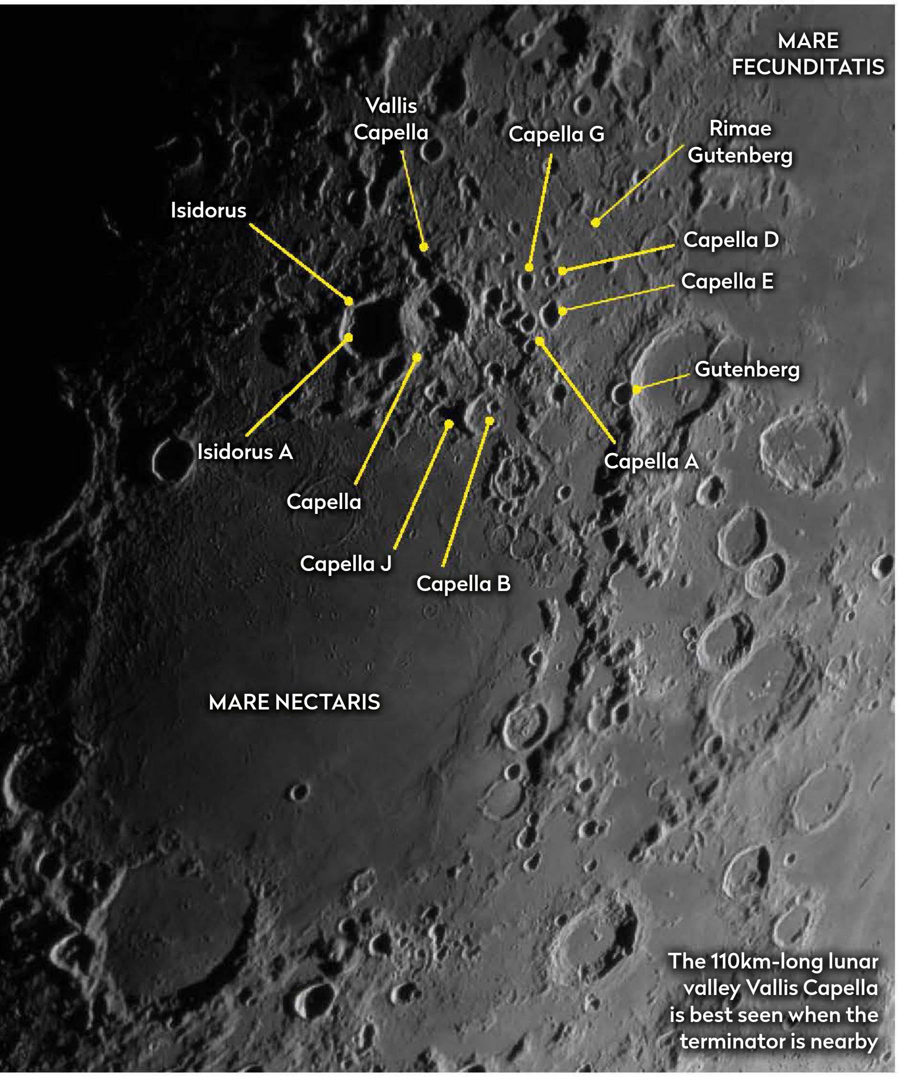
Type: Valley
Size: 11km x 110km
Longitude/latitude: 35° E, 7.4° S
Age: Older than 3.9 billion years
Best time to see: Five days after new Moon (4 March) or four days after full Moon (18–19 March)
Minimum equipment: 100mm telescope



The Moon's surface is covered in many impressive valleys. Some are true geological valleys, while others have been formed by impactors breaking apart before crashing down onto the Moon's surface. When this occurs, it forms a crater chain that in some cases is structured enough to be recognised as a valley. A classic example is the spectacular form of Vallis Rheita.

> ***Vallis Capella is a spear-shaped rift that passes through the 50km crater Capella***

PETE LAWRENCE X 3



The 110km-long lunar valley Vallis Capella is best seen when the terminator is nearby

Vallis Capella also appears to fall under this category, a spear-shaped rift that passes through the 50km crater **Capella**, located immediately to the north of 350km **Mare Nectaris**. The valley is distinctive in shape, widest at the northwest end where its initial impact crater is 16.5km across. Subsequent impacts get ever smaller until the valley peters out to the southeast of Capella with craterlets barely 3km in diameter. Looking at wider photographs of the area may suggest the valley continues further to the southeast, but on closer inspection this appears to be a visually suggestive chance alignment of gaps within the local highland region and it's unlikely that anything persists from the point 30km northwest of 8.4km **Capella B**.

Vallis Capella doesn't appear to be precisely on target with respect to Capella either, with the main form of the valley running through the northeast section of the crater, passing between the crater's rim and its distinctive central mountain. Capella has a depth of 3.5km, its central mountain rising to a height of around 1.2km above its floor. Actually, there's not much floor to speak of, as Capella's sharp but irregular rim terraces reach into the centre of the crater then rise to the central peak before any significant floor area can be formed.

To the east of Capella is a region containing a number of similar-sized craters. Several of these are interesting because they are on the ALPO (Association of Lunar and Planetary Observers) list of bright ray craters. These include **Capella A** (11.8km), **Capella D** (8km), **Capella E** (14.3km) and **Capella G** (11km), as well as **Capella J** (8.9km) which is located south of Capella.

To the immediate west of Capella is 41km **Isidorus**, marginally smaller than Capella but better defined. Isidorus has steep inner slopes showing no terracing. The rim walls lead down to a flat floor and there's no central mountain complex. The main features on Isidorus's floor are two craterlets: 9.9km **Isidorus A** which overlaps a shallow and unnamed 5.3km craterlet to its immediate north.

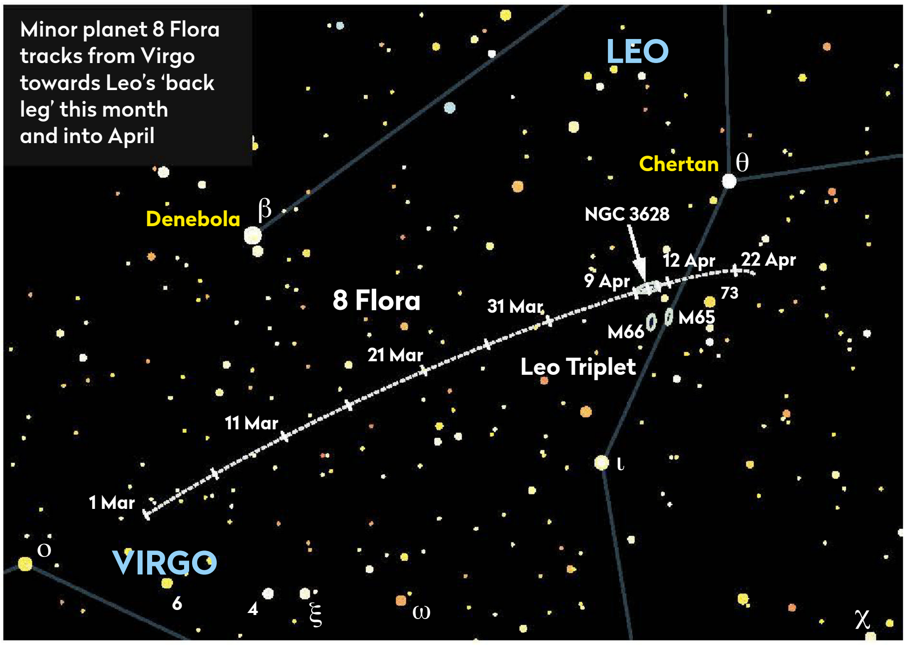
When observing the region, don't forget to head a little to the northeast, beyond the similar-sized crater field immediately east of Capella. Here runs a set of northwest-to-southeast rilles known as **Rimae Gutenberg** after 75km **Gutenberg**, the first large crater reached by travelling due east from Capella. The rilles run for around 330km but are narrow, at only 2km across. To see them, you'll need a large telescope around 300mm diameter or a high-resolution imaging setup. A nearby terminator and good seeing are a real bonus when trying to pick out hairline features like this too.

COMETS AND ASTEROIDS

Follow 8 Flora with a small scope as it heads into Leo

Minor planet 8 Flora reaches opposition on 12 March when it can be found shining at mag. +9.6 within Leo, the Lion, south of Denebola (Beta (β) Leonis), the star that marks the end of the lion's tail.

Flora begins the month as a mag. +9.8 object in Virgo, 2.3° west-northwest of mag. +4.1 Omicron (ο) Virginis and adjacent to the Virgo–Leo border. It's a solid target for a small telescope but too faint for average binoculars. Its track takes it in front of the mag. +10.4 edge-on spiral galaxy NGC 3628, the northernmost galaxy in the famous Leo Triplet group located within the 'back leg' of Leo, mid-way between mag. +3.3 Chertan (Theta (θ) Leonis) and mag. +4.0 Iota (ι) Leonis. NGC 3628 is known as the Hamburger Galaxy due to its sideways appearance and thick, dark central dust lane. The crossing occurs on 9–12 April, when Flora will have dimmed to mag. +10.3 – still within small telescope range and ideal for imaging.


Minor planet 8 Flora tracks from Virgo towards Leo's 'back leg' this month and into April

Flora is a large minor planet with a mean diameter of 128km, with a relatively high albedo how much light it reflects) of 24.3 per cent. At favourable oppositions, it can brighten to mag. +7.9 but is also capable of dimming to +11.6. This month's opposition presents Flora roughly in the middle of this range. Flora has the second-closest mean orbital distance of the main-belt asteroids, at 2.20 AU.

STAR OF THE MONTH

Alphard, the watersnake's lone bright star

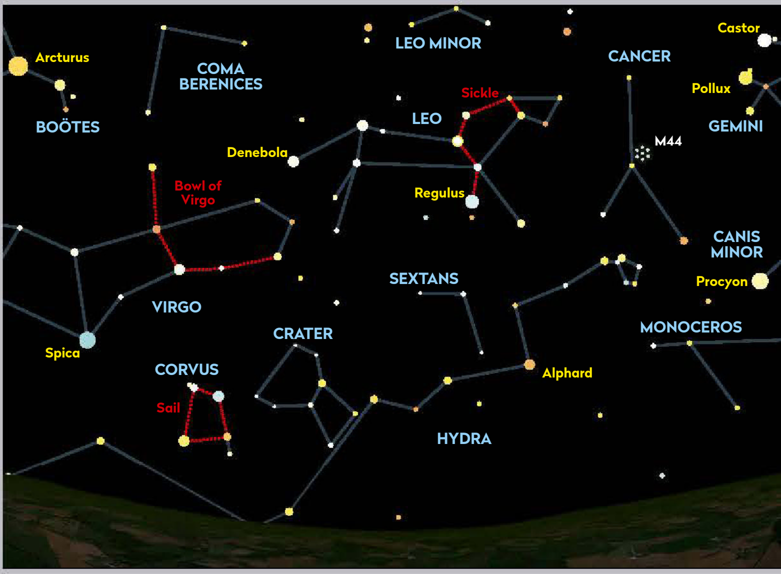
Hydra, the Watersnake is the largest constellation in the night sky. Despite this, it's also one of the most obscure, its extended body zig-zagging to the east below Cancer, Leo, Sextans, Crater, Corvus and Virgo, defined mostly by indistinct stars. Two notable exceptions are a sideways teardrop pattern of stars south of Cancer that marks the creature's head, and Hydra's brightest star, Alphard (Alpha (α) Hydrae).

Located 177 lightyears away, Alphard shines at mag. +2.0. Its name means 'the individual', referring to the fact that it sits in a region of sky with few other bright objects around it. One alternative name for it is Soheil al Fard, which translated into Latin as Soheil Solitarius, the bright solitary one.

It's an orange-hued star of spectral type K3 IIIa, the IIIa indicating a luminous normal giant. Its mass is 3.2 times that of our Sun, with a radius around 56 times larger. It rotates at 1.1km/s, a similarly leisurely pace to our Sun, which rotates at 2.0km/s.

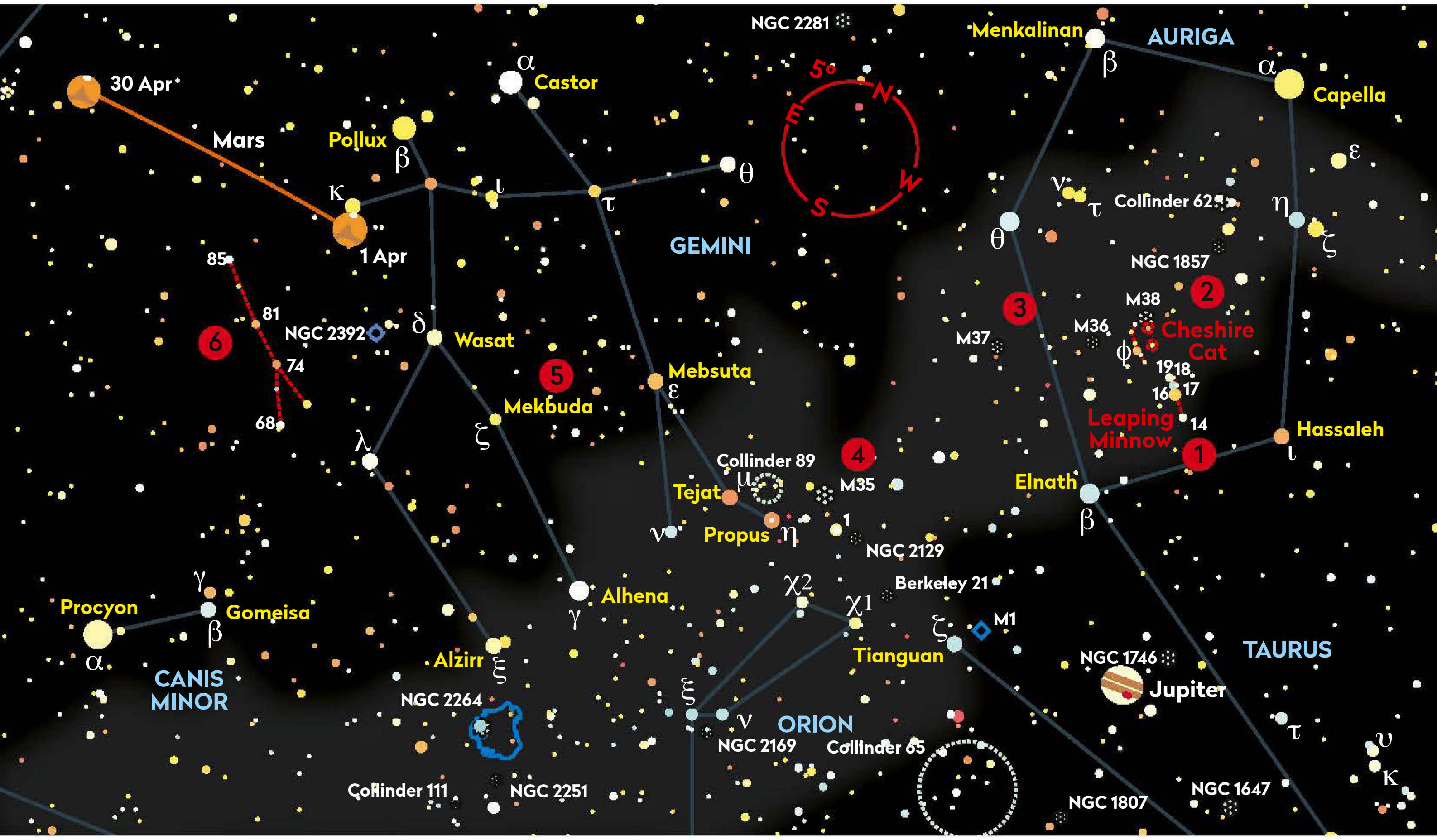
Because Alphard sits in a relatively barren patch of sky, it's a little tricky to describe how to find it. If you're familiar with the Beehive Cluster, M44, start there and head south until you arrive at the sideways teardrop pattern representing Hydra's head. The body extends southeast out of the pointed end of the teardrop to the east, curving south to arrive at Alphard – in many ways, conjuring up the shape of the classic fake photograph of the Loch Ness Monster.

▼ Orange giant Alphard is a rare luminary highlight in the faint, sprawling constellation of Hydra



BINOCULAR TOUR With Steve Tonkin

March brings an easy Cepheid variable and a flying fish supper for a happy cat


NGC 2281
Menkalinan
AURIGA
β
α
Capella
ε
30 Apr
Mars
Pollux
β
α
Castor
θ
5°
N
E
W
S
κ
ι
τ
GEMINI
ν
τ
Collinder 62
η
ζ
θ
1 Apr
85
NGC 1857
M38
2
3
81
NGC 2392
δ
Wasat
6
74
5
Mekbuda
Mebsuta
ε
M37
M36
Cheshire Cat
φ
19
18
16
17
Leaping Minnow
14
Hassaleh
ι
68
λ
ζ
Collinder 89
μ
4
M35
Tejat
Elnath
1
β
ν
Propus
η
1
NGC 2129
Berkeley 21
γ
Procyon
Gomeisa
β
α
CANIS MINOR
Alhena
γ
χ2
χ1
ζ
M1
Tianguan
Alzirr
ξ
NGC 1746
TAURUS
Jupiter
NGC 2264
ξ
ν
ORION
NGC 2169
Collinder 65
τ
υ
κ
Collinder 111
NGC 2251
NGC 1807
NGC 1647

1. The Leaping Minnow

10x50 You'll find the first of this month's asterisms (star patterns) a little more than 4° east of mag. +2.7 Hassaleh (Iota (ι) Aurigae). This little group of fifth-magnitude stars, just over a degree long, includes 14, 16, 17, 18 and 19 Aurigae. In a pair of 10x50 binoculars (and with a bit of imagination), you should see that this group of stars forms the shape of a fish leaping out of the water. ☐ **SEEN IT**

2. The Cheshire Cat

10x50 Look 1.5° to the east of the Leaping Minnow and you'll easily see yellow mag. +5.1 Phi (φ) Aurigae. This is the brightest star in a northeast-extending curve of mostly sixth and seventh-magnitude stars that covers about 1.5°. This is Alice's "grin without a cat". There's a pair of widely spaced stars – the cat's yellowish eyes – 0.5° to the west. Can you see the little group of eighth-magnitude stars that hints at the disappearing nose? ☐ **SEEN IT**

3. The Auriga trio of clusters

10x50 At the northern end of the Cheshire Cat's smile, there's a fuzzy patch. That is M38, known as the Starfish Cluster, the first of three easy open clusters in Auriga. You'll find the next one, the Pinwheel Cluster, M36, a couple of degrees to the southeast. Now place M36 at the northwest of your field of view and yet another fuzzy patch, the Salt and Pepper Cluster, M37, will be just to the left of centre. ☐ **SEEN IT**

4. M35, the Queen of Clusters

10x50 Use the chart to identify the mag. +2.9 star Tejat (Mu (μ) Geminorum) and the mag. +3.3 star Propus (Eta (η) Geminorum). M35 occupies the third apex of a base-up isosceles triangle, with the two stars at the other. This aptly named Queen of Clusters is about the same apparent size as the Moon, and even under suburban skies you should be able to resolve at least 10 stars with 10x50 binoculars. ☐ **SEEN IT**

5. Mekbuda

10x50 The period of a Cepheid variable star is proportional to its luminosity, so by measuring its period you can determine its distance by comparing its luminosity with its magnitude. Mekbuda (Zeta (ζ) Geminorum) is such a star; it varies between mag. +3.6 and +4.2 over 10.15 days, so you could easily obtain a light curve within a month. ☐ **SEEN IT**

6. The Little Crab

10x50 Flemish astronomer Petrus Plancius created some new constellations to fill in gaps between the original 48 Greek ones. For a few decades in the 16th century, Cancer Minor, the Lesser Crab, 10° east of Mekbuda, was one of these. This pretty asterism of colourful fifth-magnitude stars extends nearly 7° from mag. +5.4 85 Geminorum to mag. +5.3 68 Geminorum, looking more like a fletched arrow than a crab. ☐ **SEEN IT**

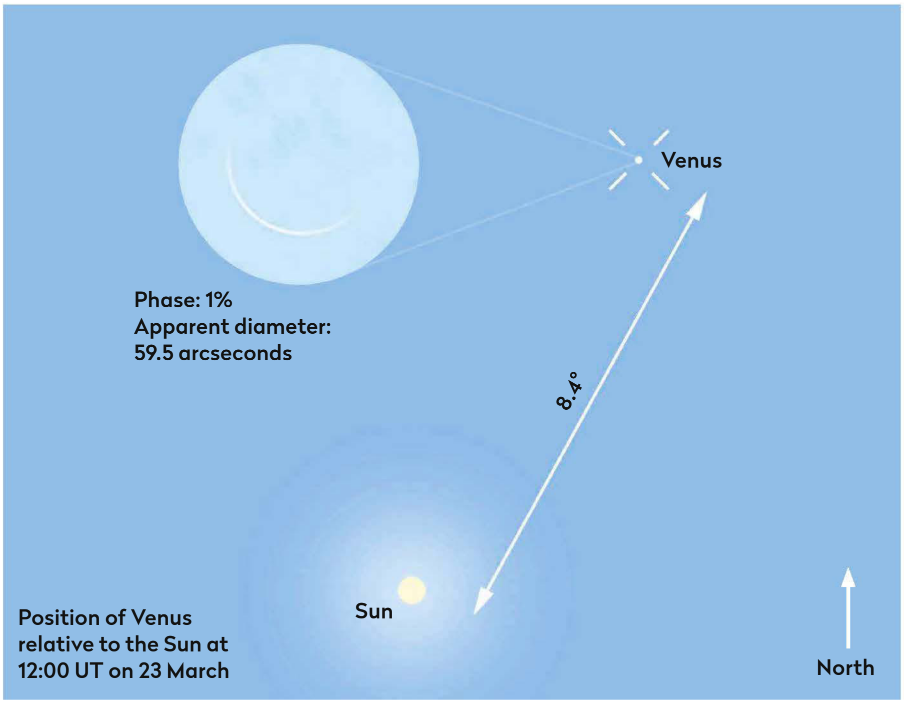
☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

CAUTION
Never observe Venus with the naked eye or any unfiltered optical instrument when it is close to the Sun

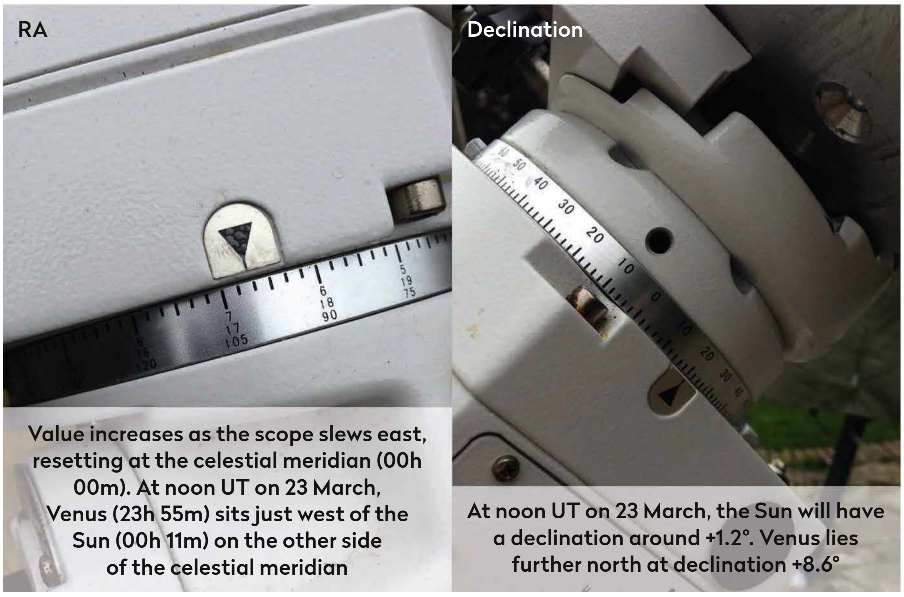
With care, capture an ultra-thin Venus as the planet lines up with the Sun



Position of Venus relative to the Sun at 12:00 UT on 23 March

Venus has been an evening beacon in early 2025, but that's about to change as the planet heads towards inferior conjunction on 23 March, the position in its orbit closest to Earth. In recent weeks, Venus has been approaching us, moving along part of its orbit closest to Earth. Its apparent sunward crawl accelerates as it moves towards inferior conjunction. Our challenge is to follow it to this position.

The orbits of Venus and Earth aren't coplanar; Venus's orbit appears to us as an ellipse. Different alignments between orbits vary the apparent width of the ellipse and under rare circumstances we see it sideways-on. When this happens, a transit of Venus occurs, the planet appearing to pass across the Sun's disc. This next occurs in December 2117.



RA

Value increases as the scope slews east, resetting at the celestial meridian (00h 00m). At noon UT on 23 March, Venus (23h 55m) sits just west of the Sun (00h 11m) on the other side of the celestial meridian

Declination

At noon UT on 23 March, the Sun will have a declination around +1.2°. Venus lies further north at declination +8.6°

▲ Using setting circles to locate Venus. Awkwardly, Venus and the Sun sit either side of the celestial meridian (RA 00h 00m) on 23 March, so you'll need to slew your scope slightly west

Venus will appear as a large but very slender crescent. It's quite something to behold

The minimum apparent separation of Venus from the Sun's centre can vary between less than 15 arcminutes during a transit event and nearly 8.5°. This year's inferior conjunction will see Venus separated from the Sun by 8.4°; that's near to the maximum but still dangerous to observe. We recommend doing this challenge with an imaging setup, never looking visually through any instrument, especially a finderscope.

There are various ways to locate Venus at inferior conjunction, but all require maximum solar safety procedures. One method is to apply a full-aperture solar filter to your telescope and remove or cap any finders. Using a mount with setting circles, centre on the Sun, focusing your camera as accurately as you can on its surface details. Look up the Sun's RA and declination coordinates; apps such as WinJUPOS and Stellarium provide these. Set your setting circles to match, then look up the RA and declination coordinates of Venus. Move your scope so the circle values match Venus's position. As a sense check, the scope should now be pointing north and away from the Sun. Carefully remove the solar filter. If Venus isn't visible, a slow spiral search pattern can be employed to locate it. Be very careful here. If your slew speed is too high, there's a danger you might slew into the Sun! If you're unfamiliar with setting circles, try using them to jump between nighttime objects as a practice exercise.

Alternatively, if you have a polar-aligned equatorial mount with Go-To capability that allows you to use the Sun as a sync object, using the same filter procedures you should be able to locate Venus using this technique too. Finally, remember what you're looking for. Venus will appear as a large but very slender crescent. When you find it, it's quite something to behold.

DEEP-SKY TOUR

We've cooked up six fascinating sights to savour around the Saucepan in Ursa Major

1 M97

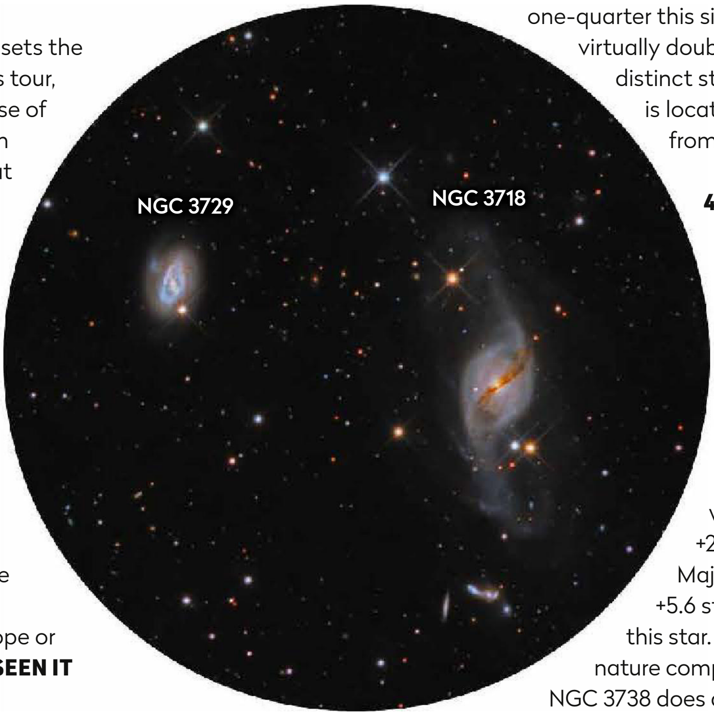
The iconic Saucepan sets the scene for this month's tour, more specifically around the base of the pan where you'll find the dim Owl Nebula, M97, staring back at you. Located a little under 2.3° southeast of mag. +2.3 Merak (Beta (β) Ursae Majoris), this mag. +9.9 planetary nebula, 2,030 lightyears away, is a large 3.3 arcminutes across, giving it low surface brightness. A 150mm scope shows it as a gently glowing disc, but you'll need a 250mm aperture to pick out the two 50-arcsecond dark 'holes' that resemble the eyes of an owl. The central star shines dimly at 16th magnitude, requiring a large scope or an imaging setup to record. ☐ **SEEN IT**

2 M108

Located 48 arcminutes northwest of M97, Messier 108 is a 10th-magnitude barred spiral galaxy 46 million lightyears away. Its orientation relative to our line of sight is tilted by 75°, which gives it the appearance of an elliptical elongated object approximately 8 x 2 arcminutes in apparent size. A 150mm scope shows a mottled texture but it's relatively uniform in brightness through such an aperture. Larger apertures will show that the central region is brighter than the surrounding spiral arms. A 300mm scope begins to hint at dark lanes between the arms, emanating from the core. M108 is one of the fainter Messiers and has been nicknamed the Surfboard Galaxy. ☐ **SEEN IT**

3 NGC 3631

While M108 is highly inclined to our line of sight, our next stop-off, the spiral galaxy NGC 3631, is virtually face-on. It's located 2° southeast of M97 – extending the line from M108 through M97 for 2.6x takes you straight to it – and listed at mag. +10.1. However, its face-on nature means its surface brightness is quite low, making it a difficult target for smaller apertures. A 250mm scope shows it as a circular glow approximately 2 arcminutes across. A small, bright central core can be seen, roughly one-quarter this size. A 300mm instrument virtually doubles its size and reveals its distinct star-like nucleus. NGC 3631 is located 33.7 million lightyears from Earth. ☐ **SEEN IT**



▲ **Our fifth and sixth targets are an interacting pair of galaxies 48 million lightyears away**

THOMAS HENNE/CCDGUIDE.COM

4 NGC 3738

Our next target is fairly dim too. NGC 3738 is a mag. +12.0 dwarf galaxy visible as a 1.5 x 1.0-arcminute glowing patch through a 250mm scope. It's located close to the base of the Saucepan's pan. Imagine a position roughly two-thirds the way from Merak towards mag. +2.4 Phecda (Gamma (γ) Ursae Majoris). Here you'll find a mag. +5.6 star. NGC 3738 is 0.3° south of this star. Despite its largely unstructured nature compared to say, a spiral galaxy, NGC 3738 does appear to have a decent surface brightness and shows a distinctly elongated core. Estimated to be around 10,000 lightyears across or roughly one-tenth the size of the Milky Way, NGC 3738 is around 12 million lightyears away. ☐ **SEEN IT**

5 NGC 3729

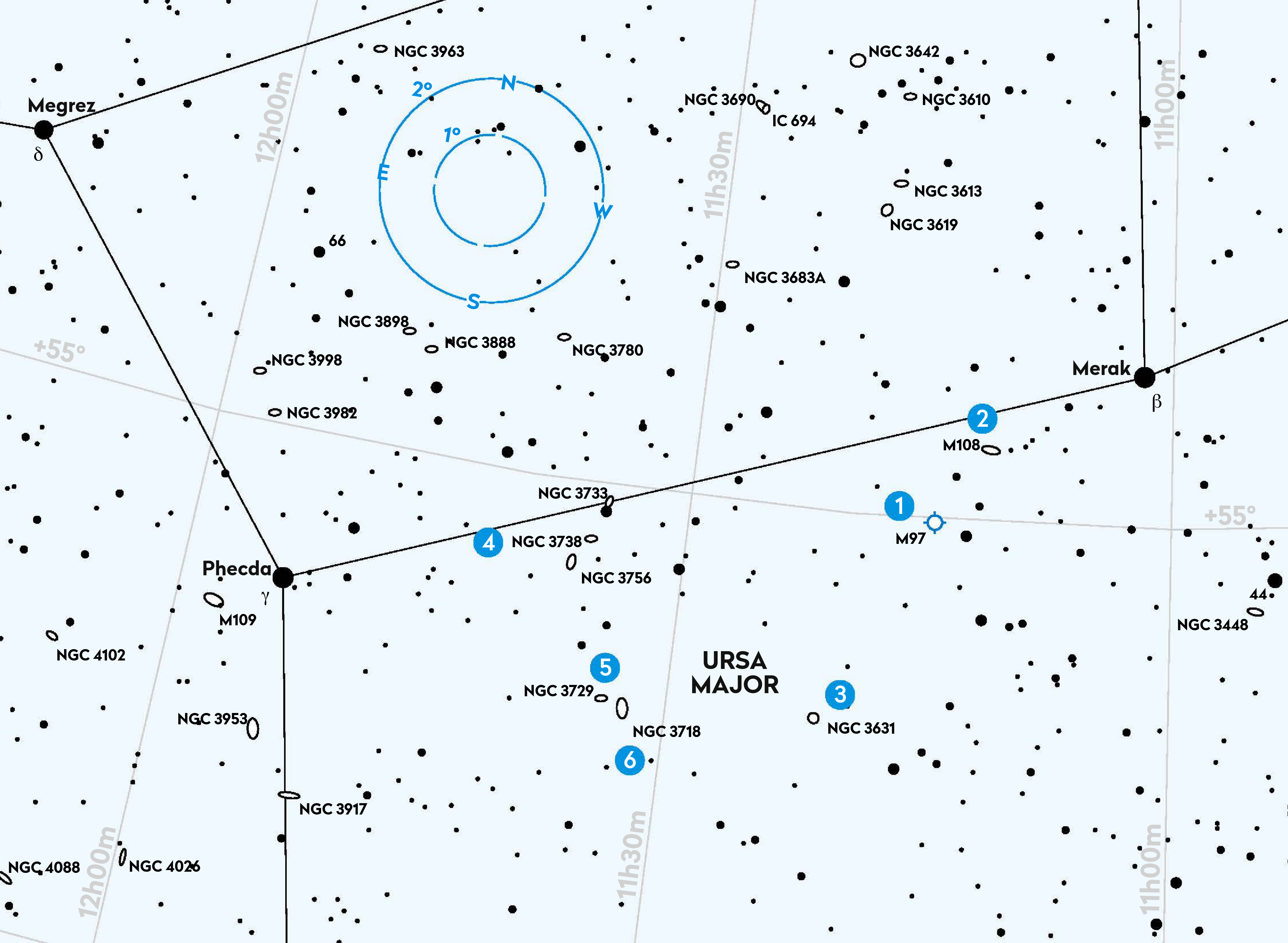
Our penultimate target is an object that is interacting with our final entry below, NGC 3718. Both galaxies are estimated to be around 150,000 lightyears apart and nearly 48 million lightyears away. As you'd expect from this, NGC 3729 and NGC 3718 appear fairly close to one another in the sky, separated by around 12 arcminutes. NGC 3729 is a barred spiral galaxy discovered by William Herschel in 1798. A 250mm scope shows a brighter core region, a 300mm instrument revealing elongations that bleed into the surrounding outer halo glow. An 11th-magnitude foreground star can be seen a little under 1 arcminute from NGC 3729's centre. ☐ **SEEN IT**

6 NGC 3718

As mentioned, NGC 3718 forms an interacting pair with NGC 3729, 12 arcminutes to its north-northeast. On paper, NGC 3718 is the brighter of the two, with an integrated magnitude of +10.7 versus mag. +11.4 NGC 3729. However, the larger total size of NGC 3718 at 8.7 x 4.5 arcminutes reduces its surface brightness significantly compared to the more compact 3.1 x 2.1-arcminute form of NGC 3729. A 250mm scope reveals very little about the object other than a uniform glow, with not much more from a 300mm instrument. NGC 3718 is also catalogued as Arp 214 in the Arp catalogue of peculiar galaxies. ☐ **SEEN IT**

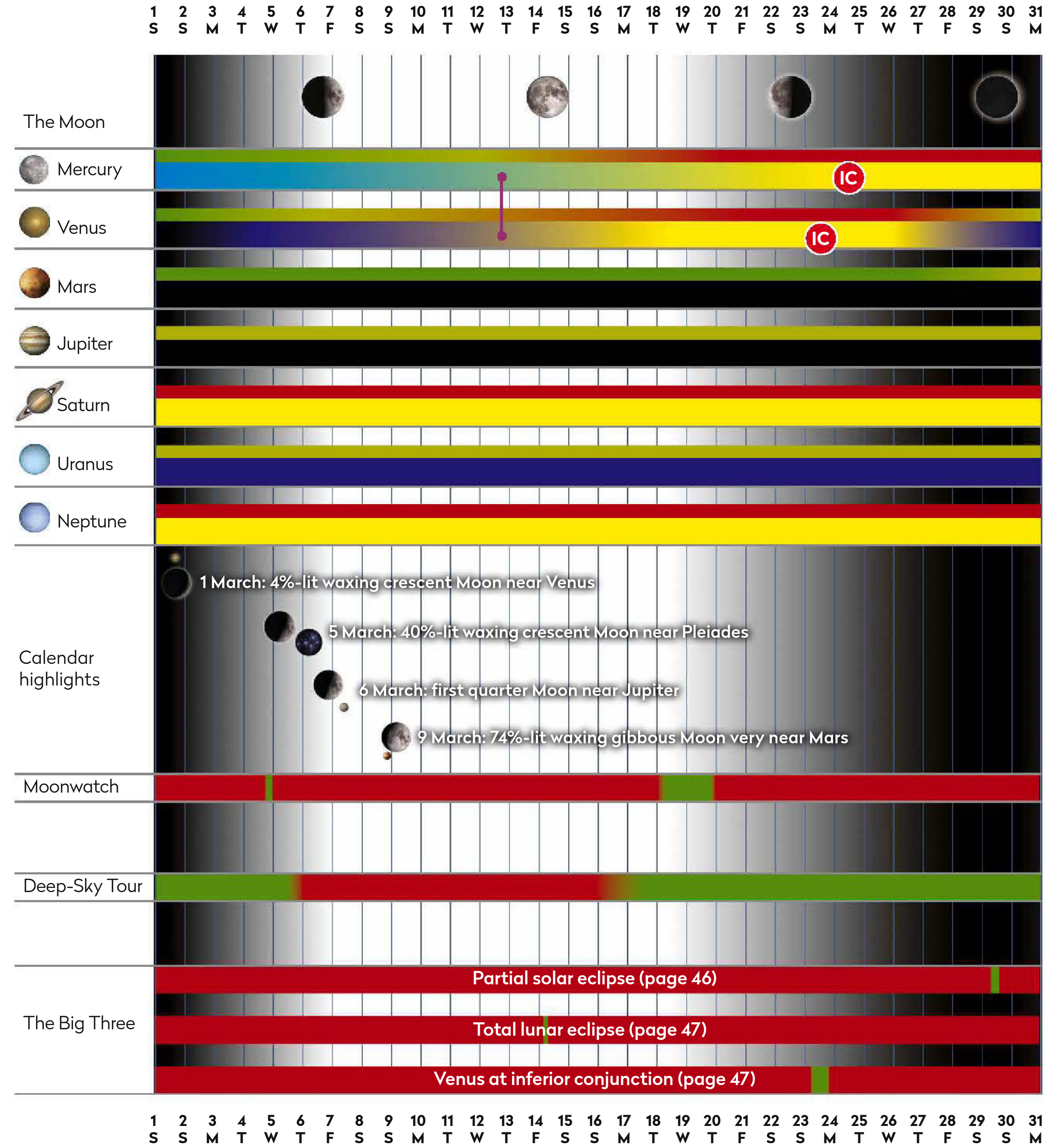
This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can take you to this month's targets at the touch of a button. Find the Deep-Sky Tour file in our free Bonus Content online.

FREE BONUS CONTENT
Print this chart and take the Go-To tour
www.skyatnightmagazine.com/bonus-content


NGC 3963
NGC 3642
NGC 3690
NGC 3610
Megrez
δ
2°
N
1°
IC 694
12h00m
E
11h30m
11h00m
NGC 3613
W
NGC 3619
66
NGC 3683A
S
NGC 3898
NGC 3888
NGC 3780
+55°
NGC 3998
Merak
β
2
NGC 3982
M108
NGC 3733
1
+55°
M97
4
NGC 3738
Phecda
NGC 3756
γ
M109
44
NGC 3448
NGC 4102
5
URSA MAJOR
3
NGC 3729
NGC 3953
NGC 3718
NGC 3631
6
NGC 3917
NGC 4088
NGC 4026
12h00m
11h30m
11h00m

AT A GLANCE

How the Sky Guide events will appear in March



KEY

Observability
🟩 Optimal
🟥 Poor

Best viewed
Morning twilight
🟨 Daytime
🟦 Evening twilight
⬛ Night

Sky brightness during lunar phases
Dark (first quarter)
Light (full Moon)
Dark (last quarter)
Total darkness (new Moon)

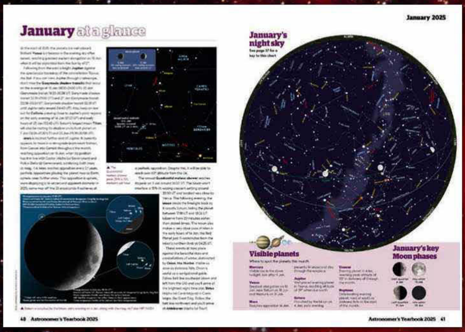
IC Inferior conjunction (Mercury & Venus only)
SC Superior conjunction
OP Planet at opposition
△ Meteor radiant peak
Planets in conjunction

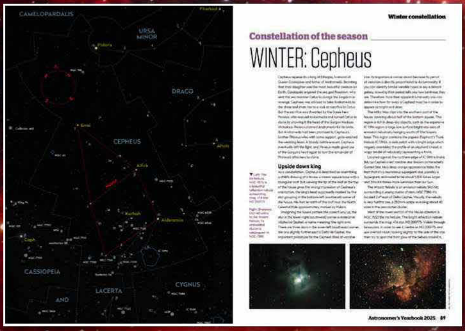
Full Moon
First quarter
Last quarter
New Moon

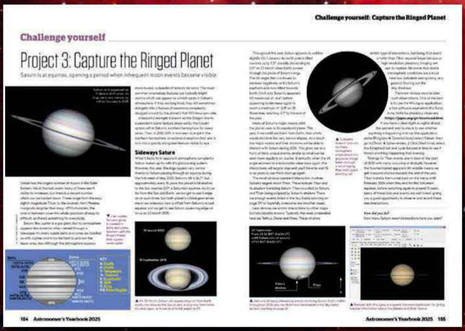
CHART BY PETE LAWRENCE

FROM THE MAKERS OF BBC Sky at Night MAGAZINE

The Astronomer's Yearbook 2025


Our month-by-month guide and detailed star charts reveal what to look for and when, from stars and planets to Moon phases and more


Get to know the stand-out constellations of each season, as we highlight their brightest targets and how to best observe them


Develop your skills with our Challenge Yourself projects, whether it's observing the valleys of the Moon or imaging Saturn's rings

BBC Sky at Night MAGAZINE

THE ASTRONOMER'S YEARBOOK 2025

Your guide to the stars for the next 12 months

The year's big eclipses, comets & meteor showers

When and where to find the planets each season

10 easy targets for your first astrophoto

Up close with beautiful Saturn, the Ringed Planet

Top tips for family friendly stargazing

ONLY £12.99* INCLUDING FREE DELIVERY!

Discover your ultimate guide to stargazing and the night sky in 2025. With 12 months of detailed star charts and expert tips on the best events to add to your observing diary, *The Astronomer's Yearbook 2025* has everything you need to make the year truly astronomical!

Chris Bramley
Editor, *BBC Sky at Night Magazine*

ORDER ONLINE

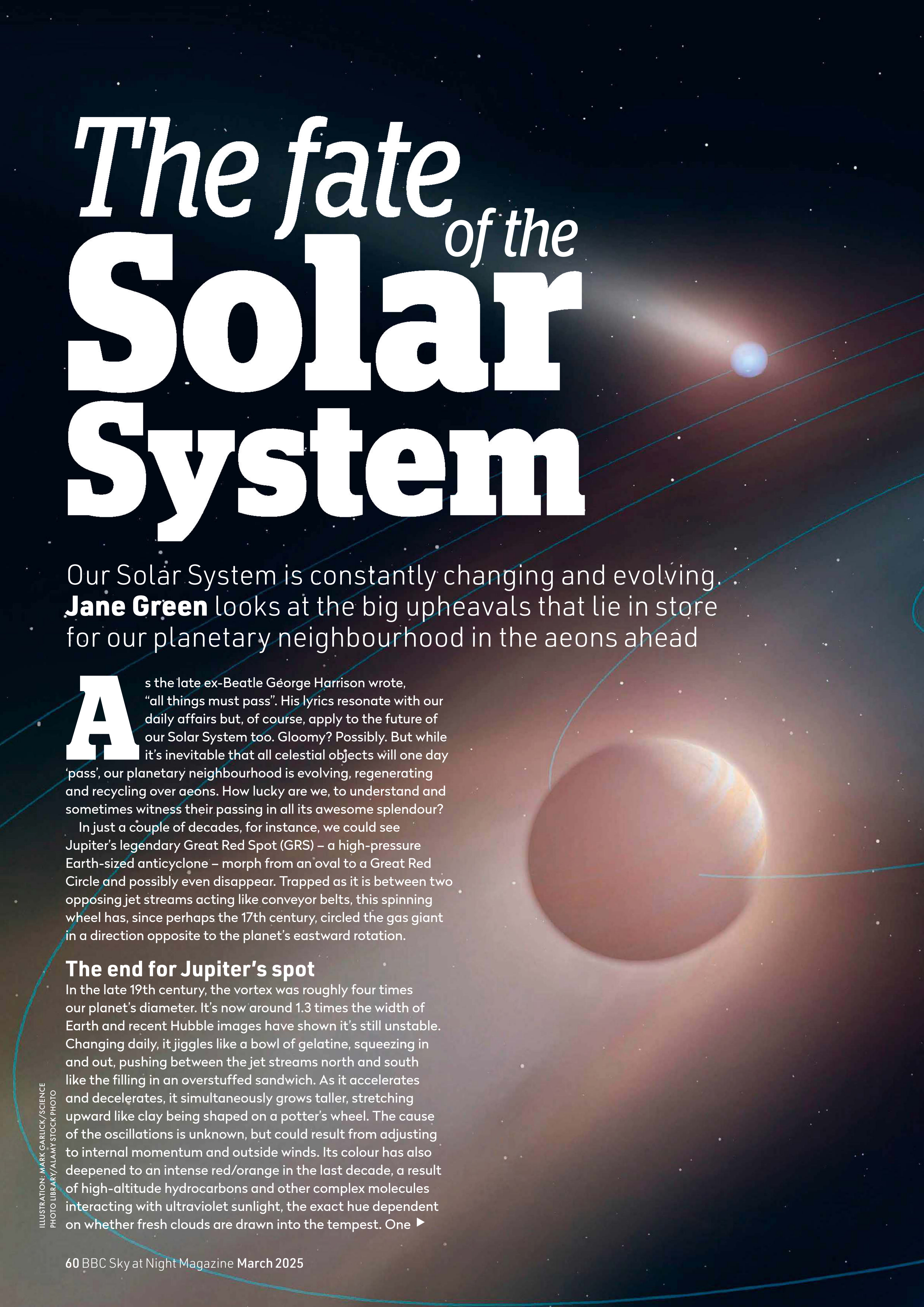
www.ourmediashop.com/AstronomersYearbook25

Or call 03330 162138† and quote 'ASTRONOMER'S YEARBOOK 2025 PRINT 1'

† UK calls will cost the same as other standard fixed line numbers (starting 01 or 02) and are included as part of any inclusive or free minutes allowances (if offered by your phone tariff). Outside of free call packages call charges from mobile phones will cost between 3p and 55p per minute. Lines are open Mon to Fri 9am–5pm. Overseas please call +44 (0)1604 973 746.
*Price above applies to UK orders only. UK residents receive FREE UK delivery. EUR price £14.99, ROW price £15.99 All orders are subject to availability. Please allow up to 28 days for delivery.

The fate of the Solar System

Our Solar System is constantly changing and evolving. **Jane Green** looks at the big upheavals that lie in store for our planetary neighbourhood in the aeons ahead



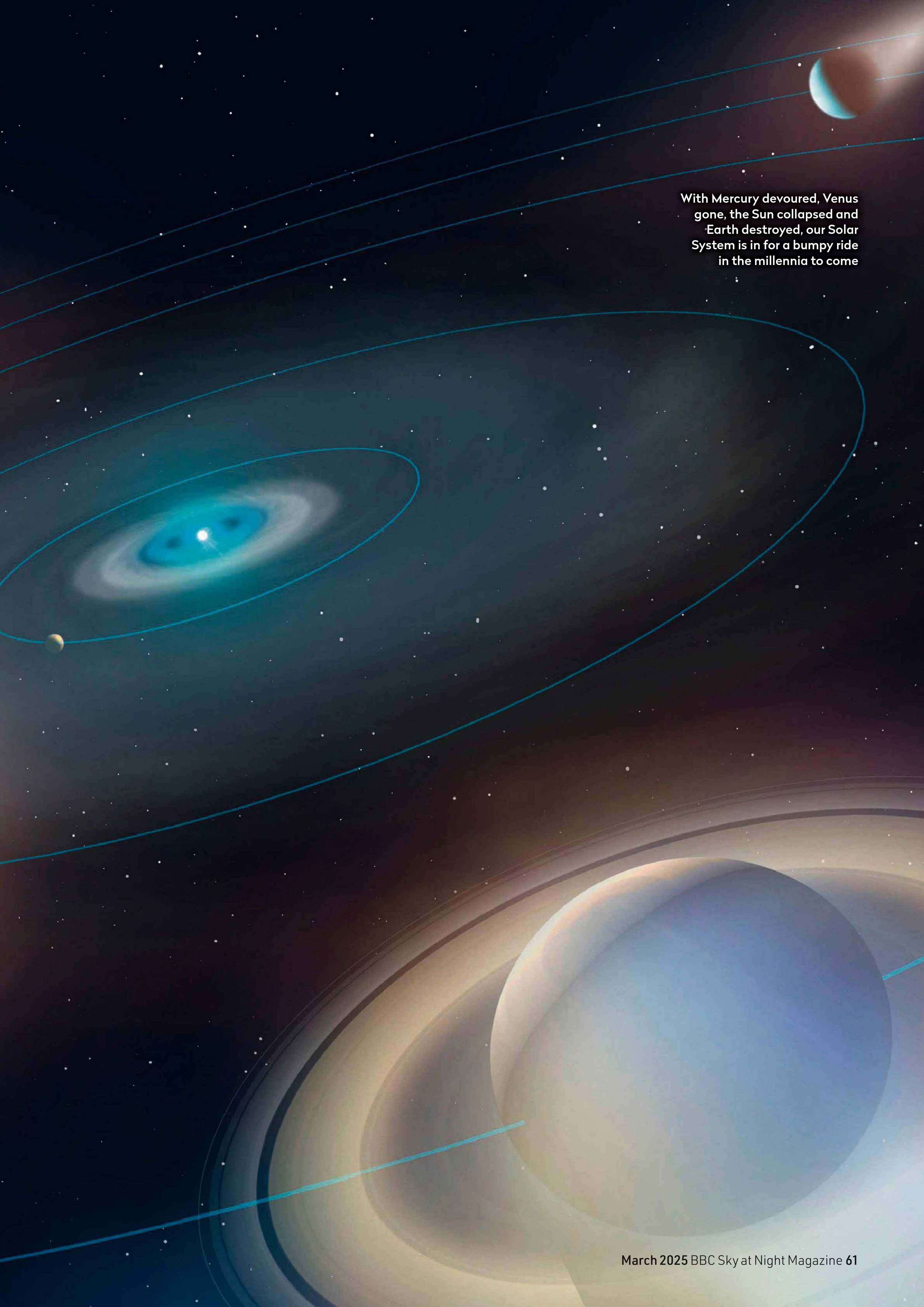
As the late ex-Beatle George Harrison wrote, "all things must pass". His lyrics resonate with our daily affairs but, of course, apply to the future of our Solar System too. Gloomy? Possibly. But while it's inevitable that all celestial objects will one day 'pass', our planetary neighbourhood is evolving, regenerating and recycling over aeons. How lucky are we, to understand and sometimes witness their passing in all its awesome splendour?

In just a couple of decades, for instance, we could see Jupiter's legendary Great Red Spot (GRS) – a high-pressure Earth-sized anticyclone – morph from an oval to a Great Red Circle and possibly even disappear. Trapped as it is between two opposing jet streams acting like conveyor belts, this spinning wheel has, since perhaps the 17th century, circled the gas giant in a direction opposite to the planet's eastward rotation.

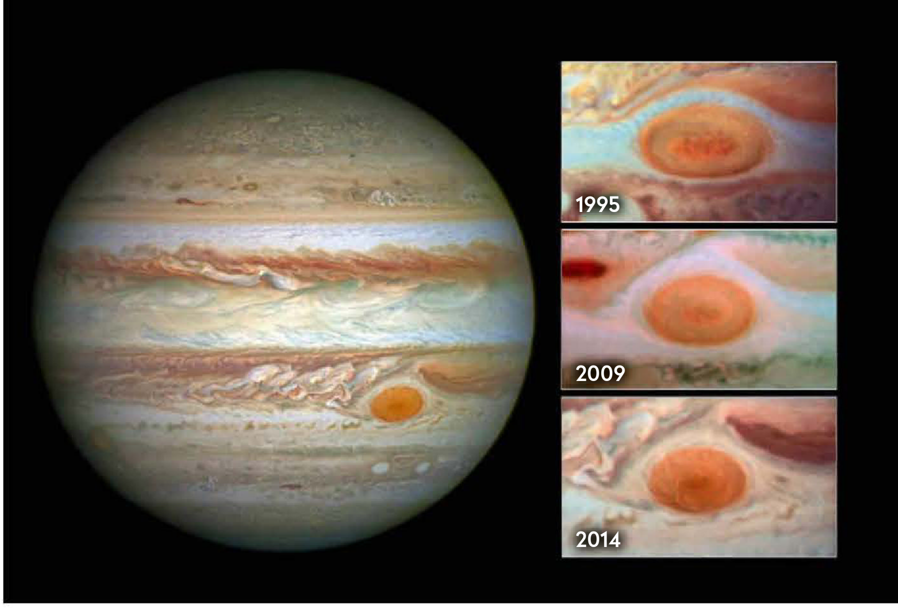
The end for Jupiter's spot

In the late 19th century, the vortex was roughly four times our planet's diameter. It's now around 1.3 times the width of Earth and recent Hubble images have shown it's still unstable. Changing daily, it jiggles like a bowl of gelatine, squeezing in and out, pushing between the jet streams north and south like the filling in an overstuffed sandwich. As it accelerates and decelerates, it simultaneously grows taller, stretching upward like clay being shaped on a potter's wheel. The cause of the oscillations is unknown, but could result from adjusting to internal momentum and outside winds. Its colour has also deepened to an intense red/orange in the last decade, a result of high-altitude hydrocarbons and other complex molecules interacting with ultraviolet sunlight, the exact hue dependent on whether fresh clouds are drawn into the tempest. One ▶

ILLUSTRATION: MARK GARLICK/SCIENCE PHOTO LIBRARY/ALAMY STOCK PHOTO



With Mercury devoured, Venus gone, the Sun collapsed and Earth destroyed, our Solar System is in for a bumpy ride in the millennia to come



▲ **Jupiter's vast superstorm is shrinking and could vanish altogether within decades**

▶ thing's for sure: the GRS is already offering a spectacular show.

Looking further into the future, Mars is also undergoing some changes. The larger of its two moons, Phobos – orbiting just 6,000km (3,700 miles) above the Martian surface – is in a gravitational death spiral, tumbling towards the Martian surface at a rate of 1.8 metres (6ft) every hundred years. Tell-tale signs of its eventual demise are already visible in the form of parallel grooves – striations – scarring the moon's terrain. Once thought to be ancient scars from asteroid impacts, according to recent modelling they are more like 'stretch marks', ever-widening dust-filled canyons resulting from the intense tidal forces between Phobos and its parent planet. The moon's interior may resemble a weak rubble pile, scarcely held together and encased by a 100-metre-thick (330ft) layer of powdery regolith which distorts and causes the surface to readjust; it moves like elastic, building stresses which ultimately cause fractures. The closer Phobos approaches Mars, the greater the tidal forces. At its current rate, it will complete its suicide spiral and hit Mars within 50 million years unless tidal forces tear it apart beforehand, in which case it will form a beautiful diaphanous ring. Coincidentally, the same fate may also befall Neptune's moon Triton, which is slowly drifting inward and has a similarly fractured surface.

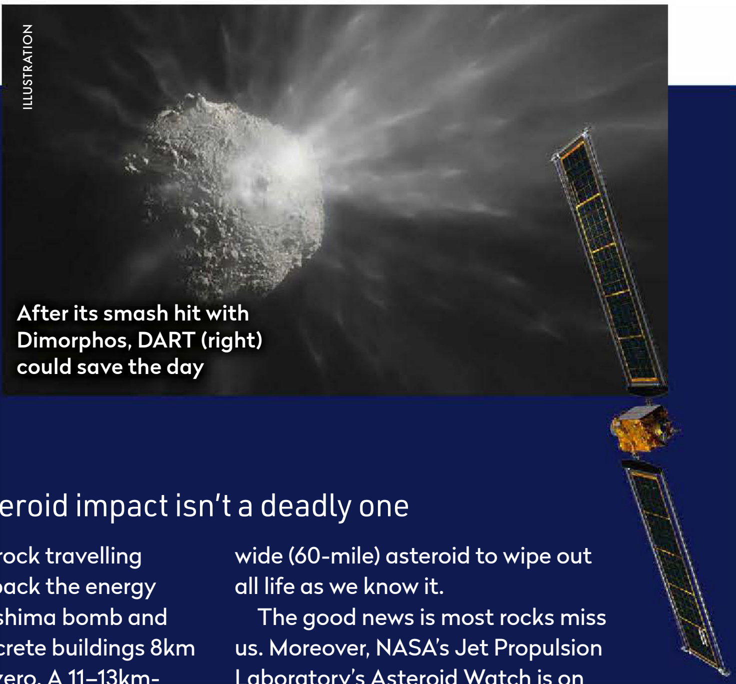
Saturn's rings fall to pieces

Peering even further ahead in time, it is estimated that, 100 to 300 million years from now, Saturn's iconic ring system may also disappear due to an erosive process called 'ring rain'. Measuring up to 1km (0.6 miles) thick and comprised of billions, if not trillions, of chunks of water ice ranging in size from a grain of sand to a mountain, these gorgeous rings have been admired ever since Galileo turned his telescope in their direction in 1610. But they're disintegrating. Every day, an Olympic-sized swimming pool of water rains down from the innermost rings onto the gas giant planet. Space

NASA/ESA, MARK GARLICK/SCIENCE PHOTO LIBRARY/GETTY X 2, ESO/M. KORNMESSER, NASA/JOHNS HOPKINS APPLIED PHYSICS LAB, NASA/JPL-CALTECH X 2, NASA/JPL-CALTECH/SPACE SCIENCE INSTITUTE/UNIVERSITY OF LEICESTER, ZXVISUAL/GETTY

ILLUSTRATION

A big one doomed the dinosaurs, but even a small asteroid could spell disaster



After its smash hit with Dimorphos, DART (right) could save the day

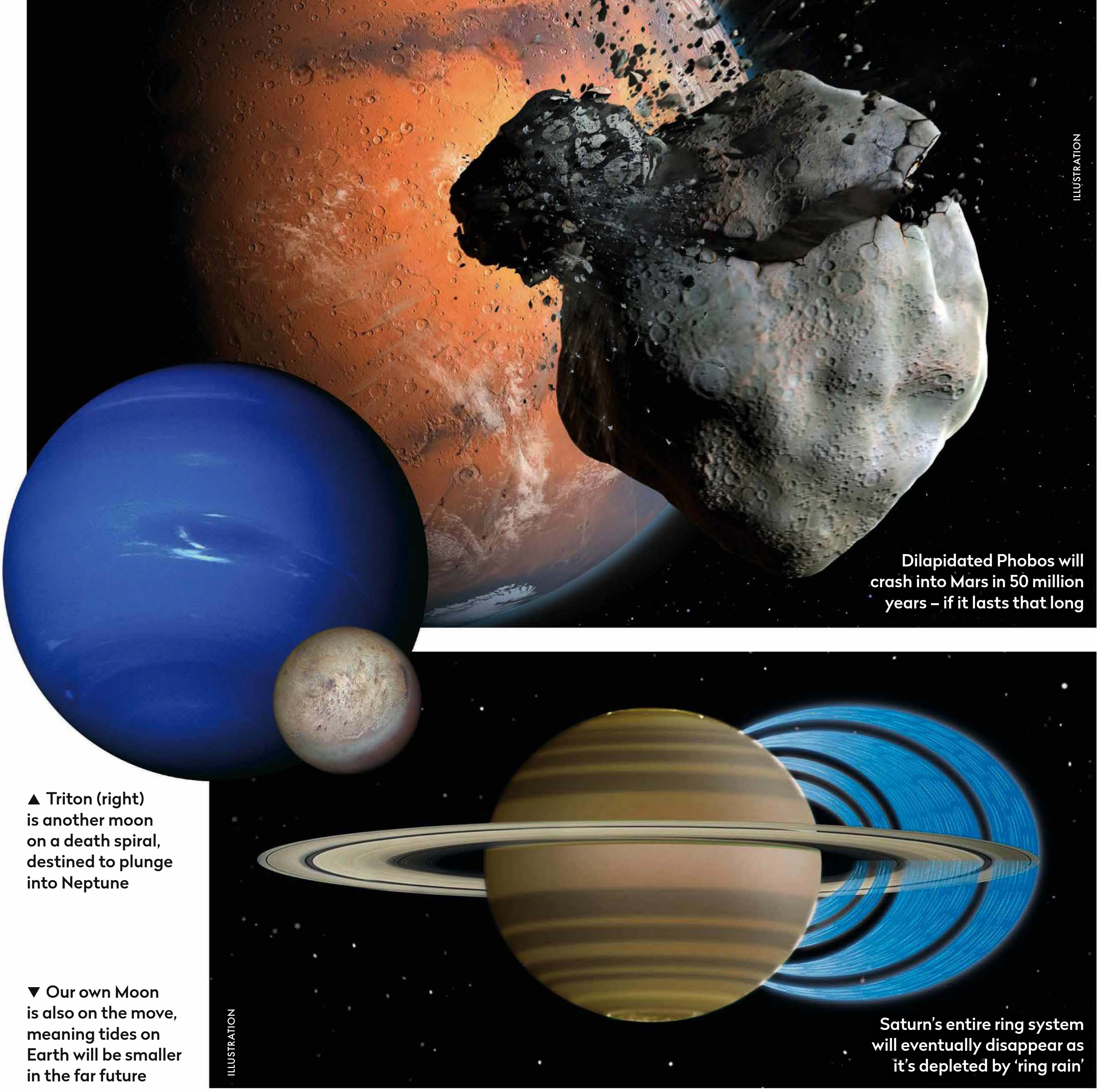
Avoiding extinction

Humanity is on the watch to ensure our next big asteroid impact isn't a deadly one

Asteroids slamming Earth is not science fiction but science fact. Variously sized space rocks have constantly swiped our planet, so it's a case of *when* not *if.* The mountain-sized asteroid that struck just off Mexico's Yucatán Peninsula 66 million years ago left the approximately 150km-wide (90 mile) by 19km-deep (12 mile) Chicxulub crater and caused the extinction of the dinosaurs. It could happen again.

Even a house-sized rock travelling at 30,000mph would pack the energy equivalent of the Hiroshima bomb and flatten reinforced concrete buildings 8km (5 miles) from ground zero. A 11–13km-wide (7–8 mile) asteroid walloping the surface would cause monstrous tsunamis, blast water and dust into the atmosphere, block sunlight and ultimately lower global temperatures. Most life would be extinguished, but it would take a 97km-wide (60-mile) asteroid to wipe out all life as we know it.

The good news is most rocks miss us. Moreover, NASA's Jet Propulsion Laboratory's Asteroid Watch is on constant lookout for threats. If there is one, the recent Double Asteroid Redirection Test (DART) on small asteroid Dimorphos proved humans can alter a rock's trajectory, possibly averting future annihilation.



ILLUSTRATION

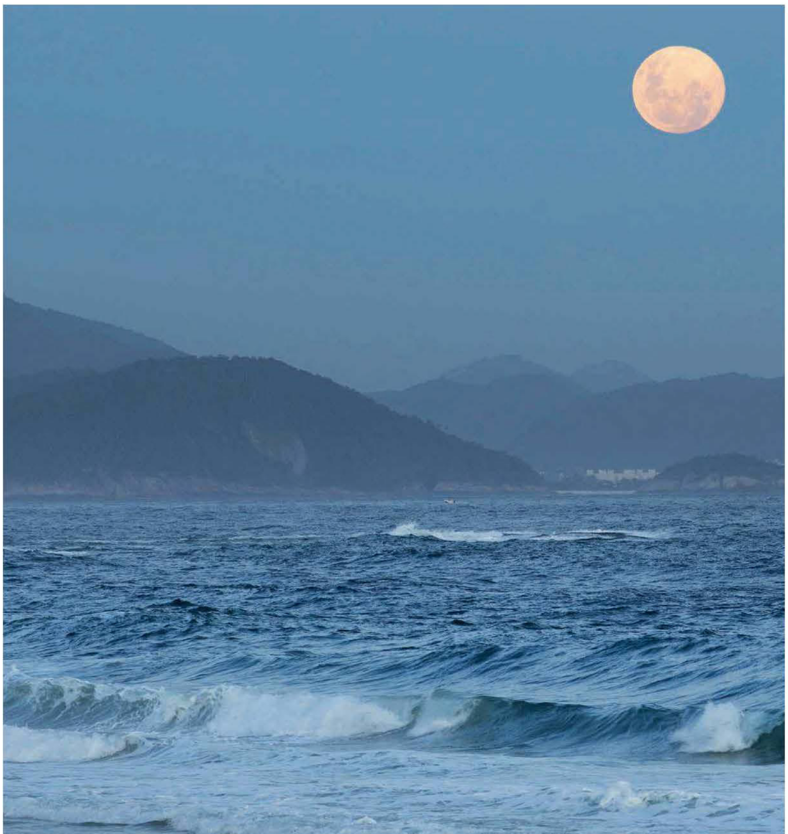
Dilapidated Phobos will crash into Mars in 50 million years – if it lasts that long

▲ Triton (right) is another moon on a death spiral, destined to plunge into Neptune

ILLUSTRATION

Saturn's entire ring system will eventually disappear as it's depleted by 'ring rain'

▼ Our own Moon is also on the move, meaning tides on Earth will be smaller in the far future



rocks and solar radiation constantly agitate the ring particles, creating an electrical charge that binds them to Saturn's magnetic field lines. The gas giant's gravity then lures these icy particles inward where, corralled by magnetic fields, they flow into the planet's upper atmosphere.

During its 29.5-year orbit, Saturn shifts towards and away from the Sun, its rings doing likewise. This tilt determines how much radiation hits the innermost rings and how much dusty material rains down. Scientists suspect that when the rings are edge-on with the Sun – as they are right now (see page 72 for more information) – the rain slows down, but future studies using the James Webb Space Telescope and the Keck Observatory will better determine just how long the ethereal icy rings will last. For now, we are just fortunate enough to witness and enjoy their expansive majesty.

Our Moon drifts away

Another departing sight might also be our own Moon, which has been slowly drifting away from us since it formed, probably after a collision with a protoplanet, ▶

▲ **With the Moon retreating from us, one day it will no longer cover the Sun – which means no more total solar eclipses**

▶ Theia, 4.5 billion years ago. When first created, the Moon was 10 times closer, a day lasted less than 10 hours and it was drifting away from Earth at a rate of 20cm (8 inches) per year. By bouncing lasers off mirrors installed on the lunar surface during the lunar expeditions of the 1960s and 1970s, astronomers can prove this drift is now 3.8cm (1.5 inches) per year and it is influencing the future of our planet.

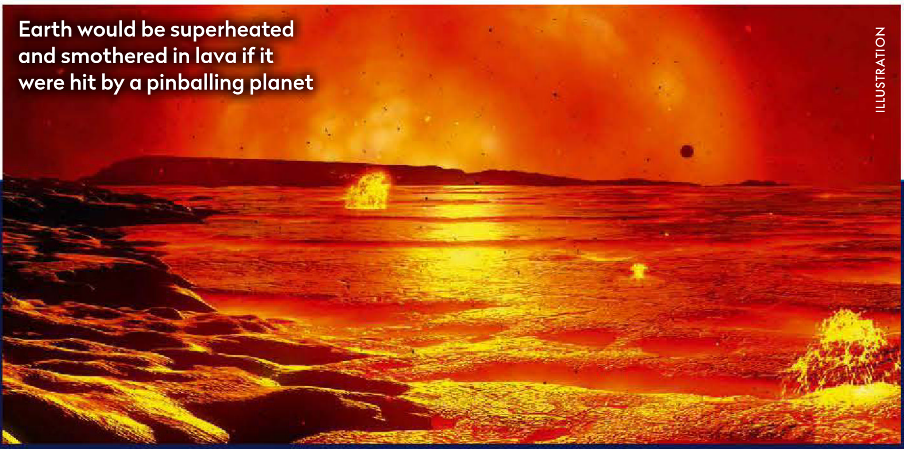
The Moon's gravity pulls on Earth's oceans, creating tides that cause drag and slow its spin rate. The resulting loss of angular momentum is compensated for by the Moon speeding up and thus drifting further away. Another reason is tidal locking; the Moon once had its own rotational spin, but Earth also exerted a gravitational pull, dissipating energy and slowing the Moon's rotation until one lunar rotation equalled one orbit of Earth. That energy dissipation continues.

As the distance increases, the Moon's pull will lessen and Earth's tides will become smaller, leading to a loss of coastal ecosystems and a change in ocean currents. These currents drive and stabilise the weather, meaning the process could cause global climate upheaval.

Equally crucially, the Moon's gravitational hold also helps stabilise Earth's tilt toward and away from the Sun – the source of the seasons. Any change in stability could make seasons obsolete.

Finally, the number and frequency of total solar eclipses will decrease as well. The Moon and the Sun appear the same size in the sky because the Sun is 400 times larger than our satellite,

KAZYU/GETTY, MARK GARLICK/SCIENCE PHOTO LIBRARY/GETTY, STOCKTREK IMAGES/GETTY, STEVEN HOBBS/STOCKTREK IMAGES/GETTY



Earth would be superheated and smothered in lava if it were hit by a pinballing planet

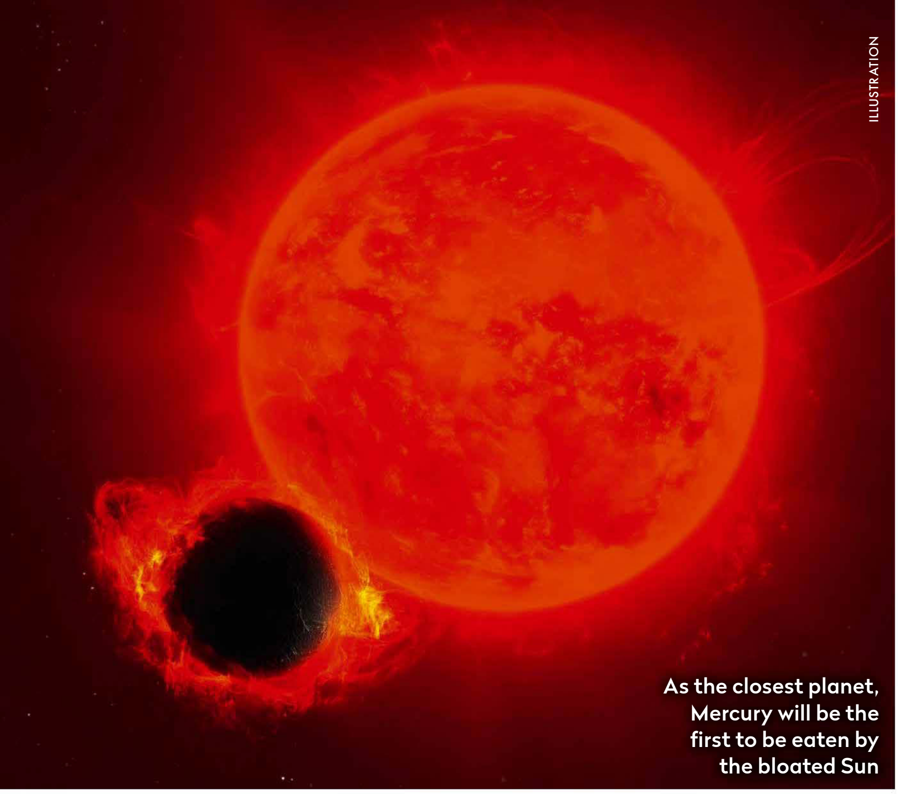
Solar System billiards

Planets could ricochet around the Solar System of the future

Astronomers think the Solar System will remain stable for 40 million years but thereafter, with gravitational tugs between the planets nudging them from their orbits, things could go awry, resulting in catastrophic collisions between Mercury, Venus, Earth and Mars.

Due to gravitational pulling from Jupiter, there is a small chance that Mercury's orbit will become seriously elongated within the next 5 billion years. If Mercury's eccentricity exceeds 0.6 (0 is a perfect circle while 1 is maximum elongation), it could cross Venus's orbit, destabilising the entire inner Solar System. Mercury and Mars, at just 6 and 11 per cent of Earth's mass respectively, would get tossed around but Venus, with 82 per cent of our planet's mass, would be harder to shift.

Mars could be flung out of the Solar System entirely after a further 820 million years, with Mercury and Venus colliding some 40 million years later. If Earth was slammed by a wayward Mercury or Mars, it would, for some 1,000 years, glow at the temperature of a red giant star, its surface smothered by lava. Simulations even suggest that in 1.3 billion years, Mercury could be tossed into the Sun. Mercifully, it's a cosmic billiard game destined for a few billion years hence and would make for a fittingly dramatic end to such a unique planet as our own.



As the closest planet, Mercury will be the first to be eaten by the bloated Sun

> “As our dying star loses half its mass, its gravitational hold on the planets will weaken and their orbits will expand”

but is serendipitously 400 times further away. Currently an average of 384,400km (238,855 miles) distant, as the Moon continues its drift it will appear smaller and smaller. In 600 million years, it will be too far away to completely block the Sun, meaning an end to total solar eclipses. In the meantime, how fortunate we skywatchers are to be around to see such a chance alignment.

Ultimately, indications suggest the Moon will cease receding in around 15 billion years' time. But long before that deadline arrives, locked in our planet's gravitational embrace, both Earth and the Moon will 'go down together', engulfed in the death throes of the enormous object anchoring our Solar System – the Sun.

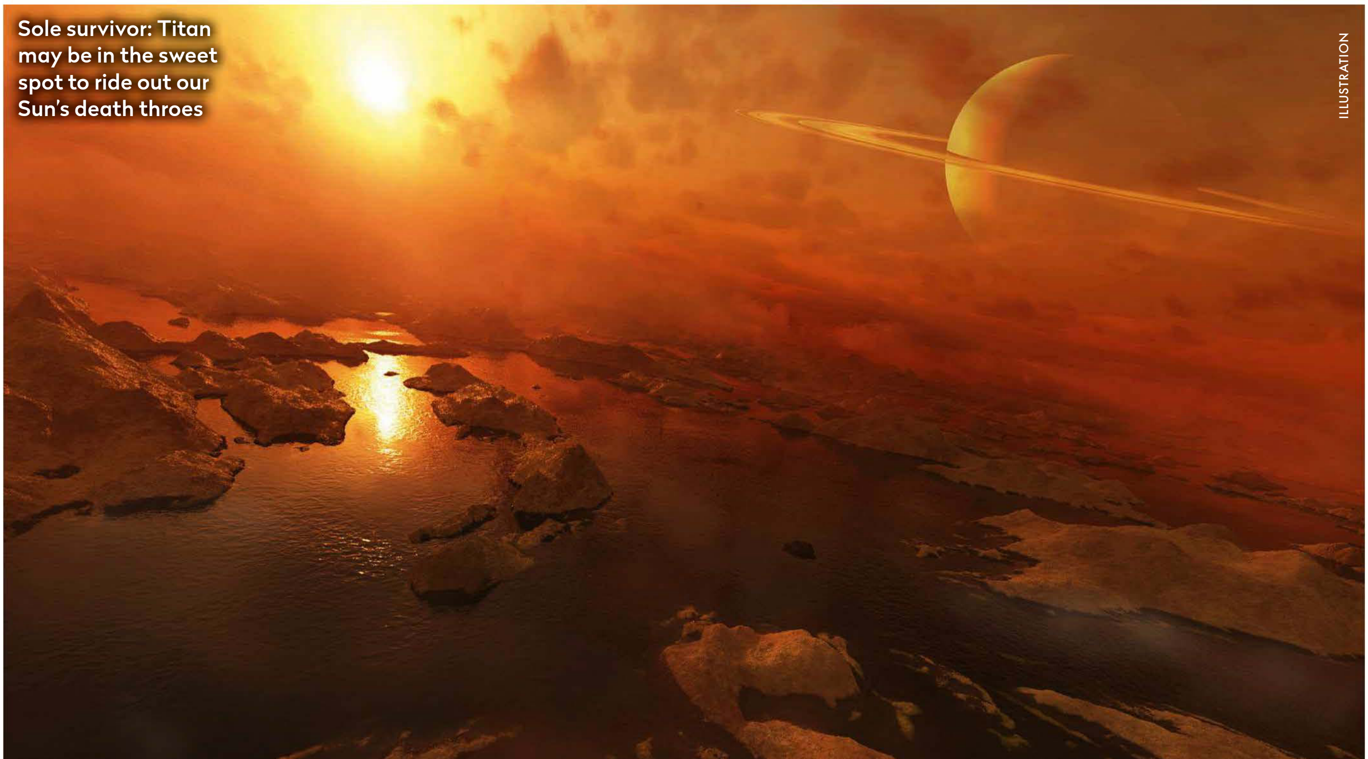
The death of our Sun

Five billion years from now, our star will exhaust its hydrogen fuel, nuclear fusion will slow and it will contract and heat up. Helium will then start to fuse into heavier elements such as carbon, nitrogen and oxygen. Hydrogen will also begin burning in the 'shell' of material surrounding the core. The collective prodigious heat will force the Sun's outer layer of gas to puff up into an enormous red giant star, its immensity filling the entire sky. Bloated and dying, it will violently eject material in intense episodic bursts, melting, evaporating and devouring the innermost planets Mercury and Venus and threatening Earth. Even if our planet survives, its surface and atmosphere will be fried by intense radiation and become uninhabitable. The atmospheres of the gas giants Jupiter and Saturn will similarly erode.

As our dying star loses around half its mass, its gravitational hold on the planets in the Solar System will weaken and their orbits will expand. The outer planets' orbits will drift outward and settle twice as far away as they are today.

But if we heed the advice of Monty Python's Eric Idle to “always look on the bright side of life”, we could turn our attention to possibly the Solar System's sole surviving real estate: Saturn's moon, Titan, its dense shrouding atmosphere offering habitability in its oceans of water-ammonia for several hundred million years. Whatever the truly long-term future holds for our solar neighbourhood, though, it is sure to be a magnificent journey.

Jane Green is an astronomy writer and author of the *Haynes Astronomy Manual*



Sole survivor: Titan may be in the sweet spot to ride out our Sun's death throes

There's something wrong with the way we use light

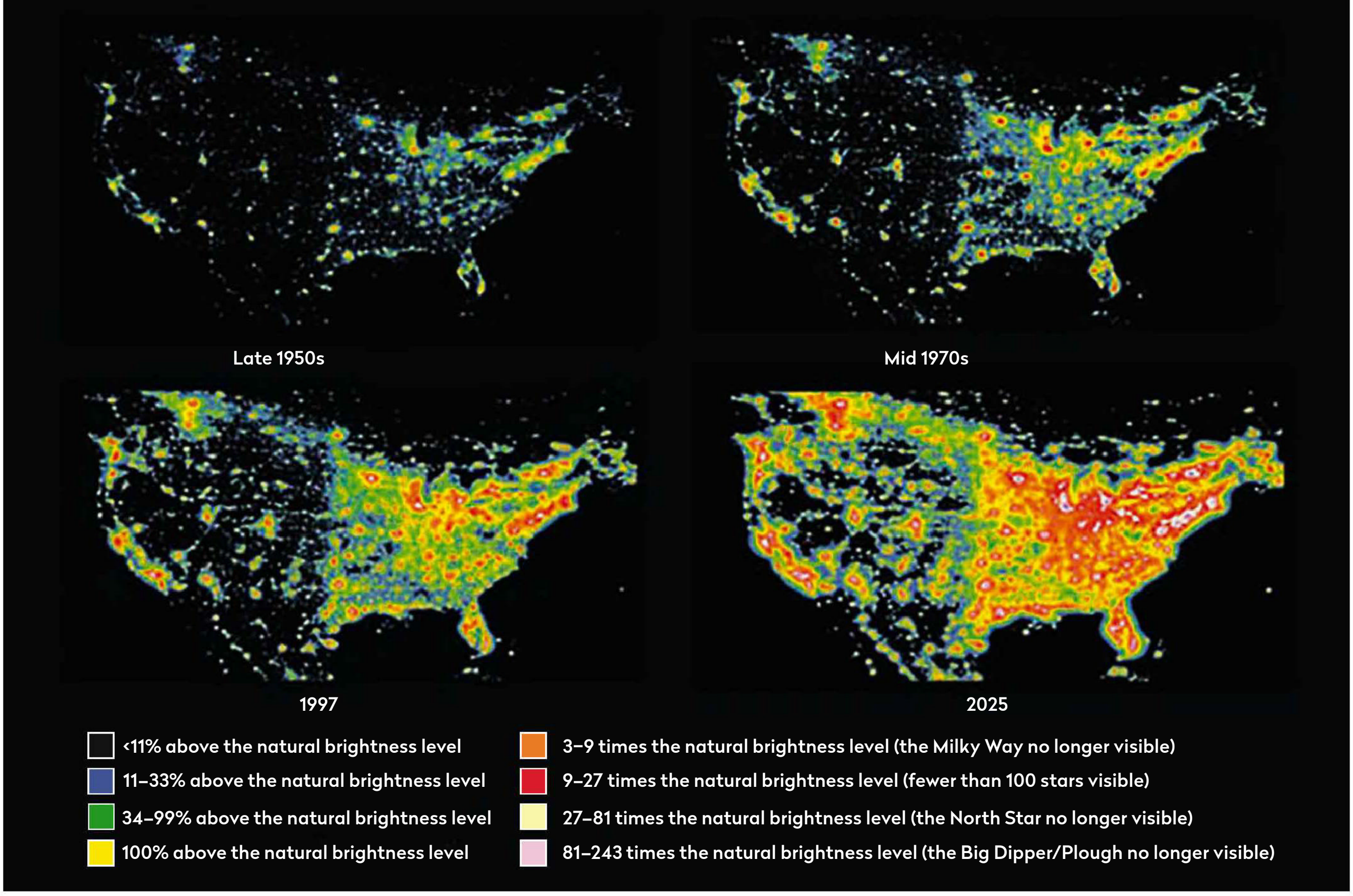
ANDREW HOLT/GETTY

Light pollution is spreading so fast that many no longer notice it. But solutions are out there. Dark-sky advocate **Paul Bogard** considers how we can reclaim the night and reduce the costs – to our health, happiness and more – of excessive artificial light

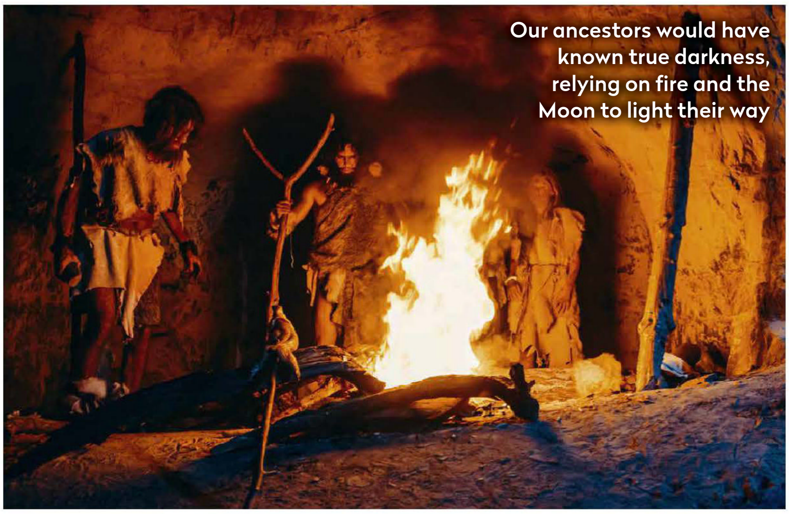
The most remarkable image to emerge from the data used to create the first *World Atlas of the Artificial Night Sky Brightness*, published in 2001, was the four views of North America that showed the growth of light pollution from the 1950s to the (then) far-off future of 2025. In one quarter of the image, the authors placed the view reflecting their 1997 data. In the other views they estimated back to the 1970s and the 1950s, and forward 25 years. Remarkably, their image that estimated the view for 2025 looks almost exactly like what the updated *Atlas*, published in 2016, went on to show.

More than any other image from the altogether stunning *Atlas*, this one helps us see what we usually don't: that because of the often excessive and unnecessary way that for decades we have lighted our nights, people in the US, Europe and elsewhere now live so immersed in artificial light that we no longer even see it. ▶

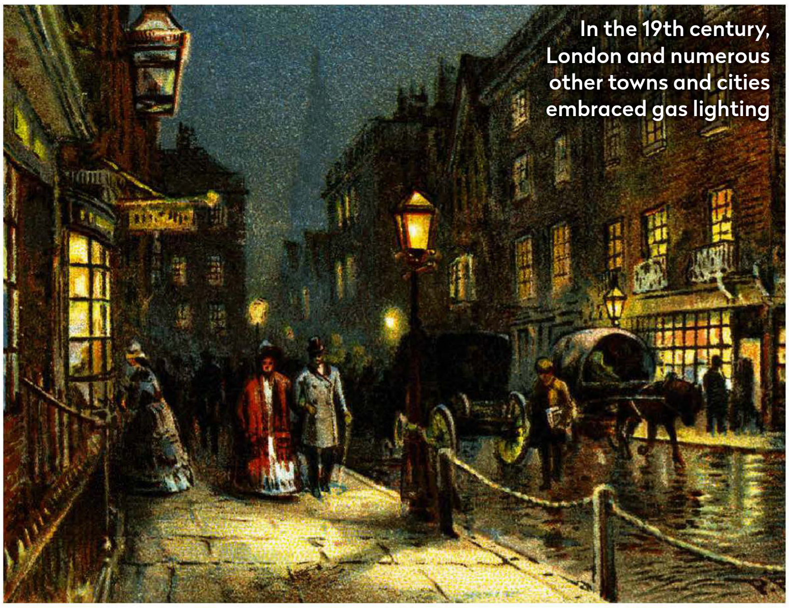
Towns and cities may be lit up 24/7, but we can push back against the misuse of light and regain our access to dark skies


Late 1950s
Mid 1970s
1997
2025
⬛ <11% above the natural brightness level
🟦 11–33% above the natural brightness level
🟩 34–99% above the natural brightness level
🟨 100% above the natural brightness level
🟧 3–9 times the natural brightness level (the Milky Way no longer visible)
🟥 9–27 times the natural brightness level (fewer than 100 stars visible)
☐ 27–81 times the natural brightness level (the North Star no longer visible)
🟪 81–243 times the natural brightness level (the Big Dipper/Plough no longer visible)

▲ **Light pollution across the United States, as recorded and predicted by the *World Atlas of the Artificial Night Sky Brightness* in 2001**



Our ancestors would have known true darkness, relying on fire and the Moon to light their way



In the 19th century, London and numerous other towns and cities embraced gas lighting

FIRST WORLD ATLAS OF THE ARTIFICIAL NIGHT SKY BRIGHTNESS/OXFORD ACADEMIC, GORODENKOFF/ GETTY, PICTORE/GETTY, ALACATR/GETTY, MARCO ROSARIO VENTURINI AUTIERI/GETTY, DSZC/GETTY

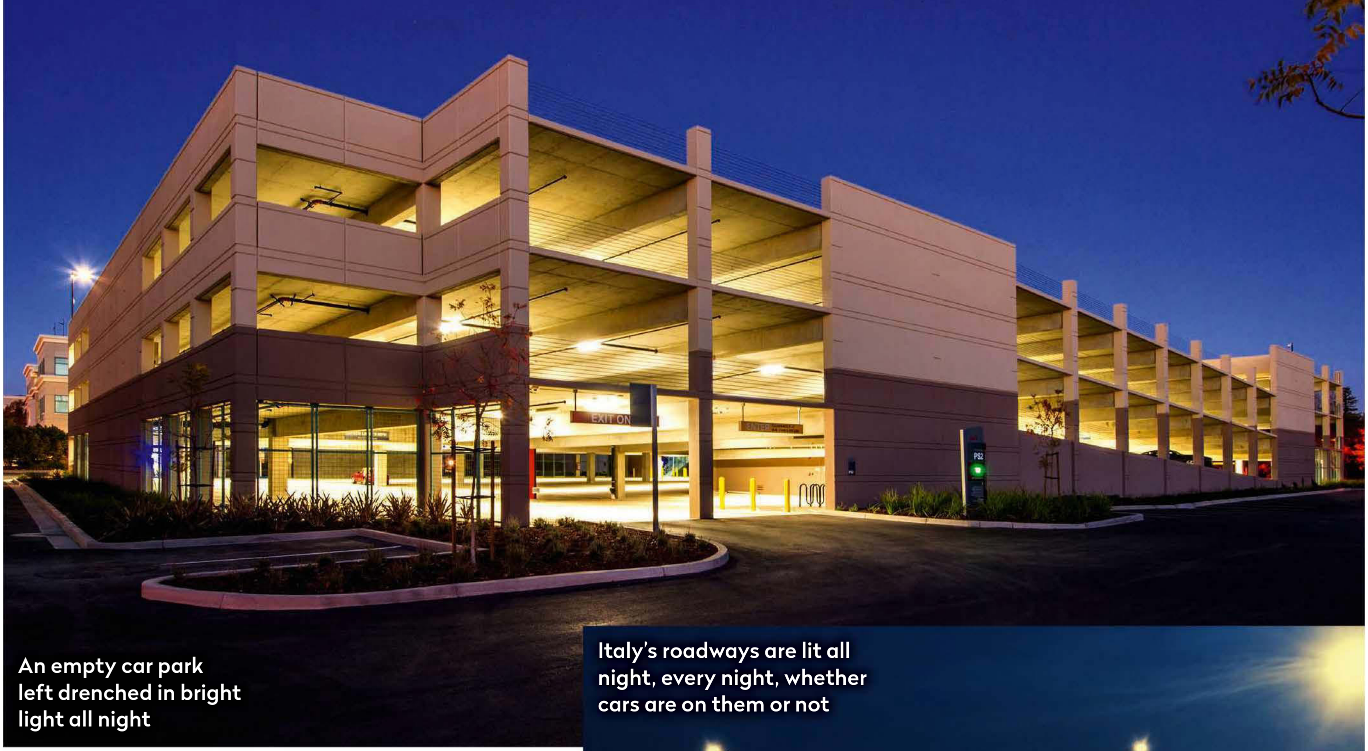
▶ We used to, of course. The first fires at night must have awed our ancestors, and oil lamps would have seemed a miracle. When gas street lighting came to Paris and London, the night opened up to city citizens in ways never before available. People took to the streets simply to enjoy strolling in the night. But with the advent of electric lighting in the 19th century, a threshold was crossed. This new technology was so much brighter than anything that had come before.

"A lamp for a nightmare" is how Robert Louis Stevenson described it in his 1878 essay 'A Plea for Gas Lamps'. Where gas lamps were dim enough to not upset our scotopic (night) vision, electric lights were blinding. As a result, we looked away. Electric light gradually became ubiquitous, but we stopped noticing. It's a trend that the newest technology of electronic lighting, LEDs, has continued. When was the last time you looked directly into a streetlight or – talk about a 'lamp for a nightmare' – cursed the LED headlights of an oncoming car?

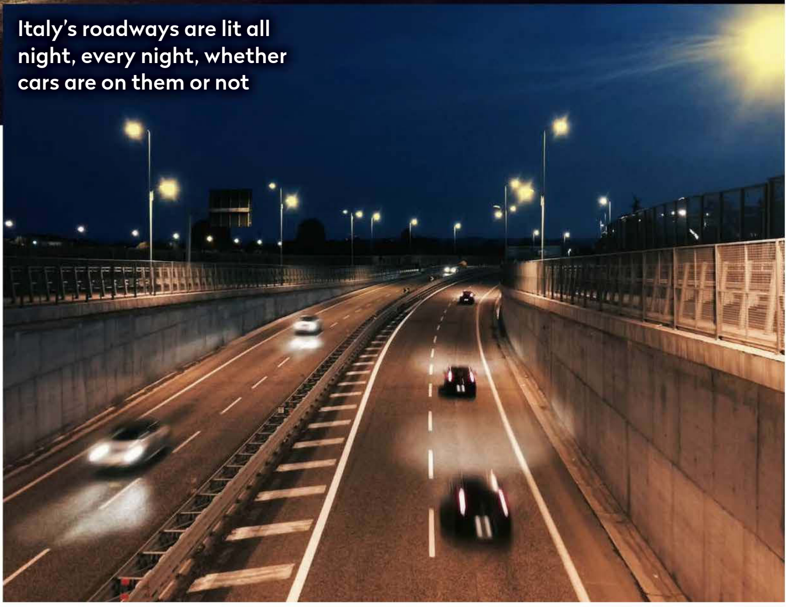
Losing darkness

In looking away, we have slowly lost the sense of what to look for, or even the understanding that our nights could look different. The growth of this overuse and misuse of artificial light – a good, short definition for what we call 'light pollution' – is an example of diminishing baseline syndrome, where each new generation takes as normal the natural world it experiences, without understanding what has been lost.

It's probably safe to say that most city or suburban dwellers under the age of 40 have never seen a naturally dark night sky. As the images from the *World Atlas* show, the conundrum of light pollution is that it spreads quickly, but also too slowly for most of us to notice. My now 80-year-old father was a



An empty car park left drenched in bright light all night



Italy's roadways are lit all night, every night, whether cars are on them or not

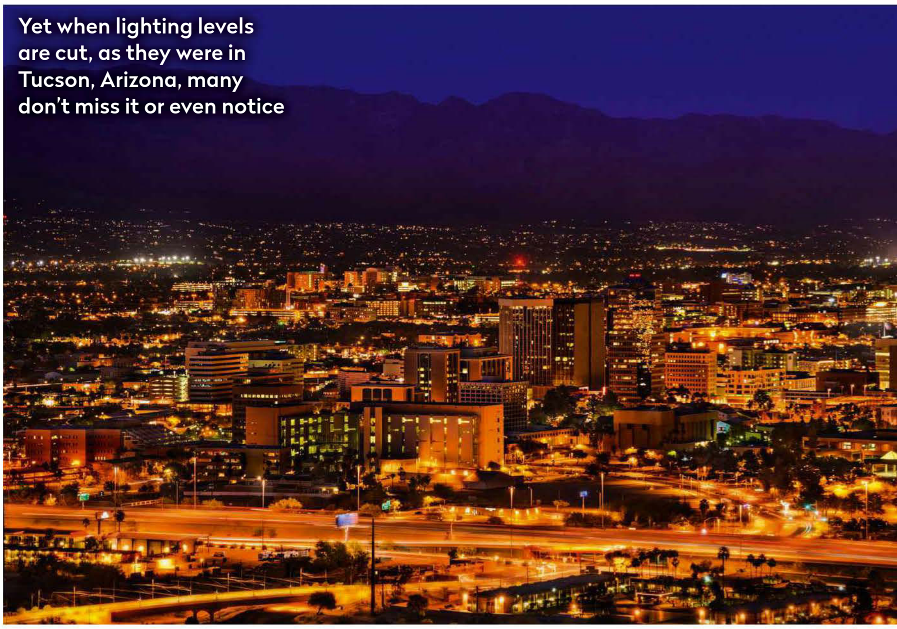
> **"It's probably safe to say that most city or suburban dwellers under the age of 40 have never seen a naturally dark night sky"**

teenager in the 1950s. In less than a single human lifetime, most of the continent has been swamped in light.

But in what ways is our use of artificial light 'wrong'? To begin with, says Fabio Falchi, the lead author of the *World Atlas*, "we light up things that should not be lighted". He cites as one example the northern Italian roadways (although it's true of other roads worldwide) that are lit all night, every night, even if few cars travel them, and with no research that doing so improves anyone's safety. And we light our nights at the same level of brightness all night long. Empty car parks are lit at 3:00am as brightly as when shoppers were present the evening before.

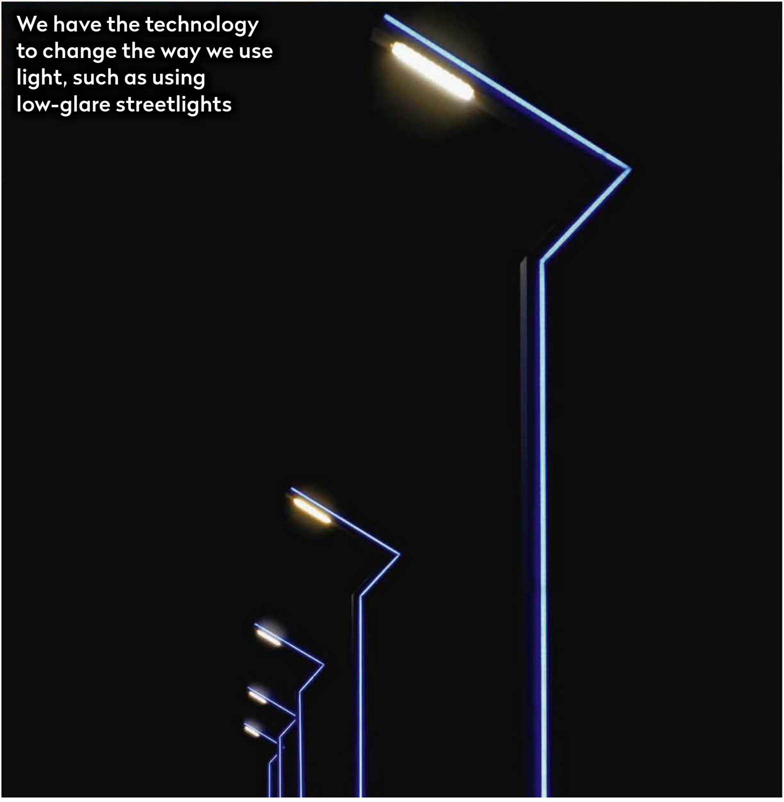
We also use far higher lighting levels than our eyes need. Lighting designers and dark-sky advocates are full of examples of how the human eye struggles to perceive higher or lower levels of light, and yet we ask for more light all the time. Ruskin Hartley, executive director of DarkSky International, says that when the city of Tucson, Arizona, recently changed its streetlights, saving $3 million on its annual energy budget and cutting its skyglow by nine per cent, "no one noticed" the lighting levels had been reduced.

The many costs from the way we light our nights are well documented. Most Americans, Europeans and city dwellers around the world will never live where they can see the Milky Way, for example, and the loss of this awe-inspiring experience has significant spiritual and psychological impacts. That we no longer can see a natural night sky is only the most obvious cost, however. Artificial light at night also brings devastating impacts to nocturnal and crepuscular wildlife; negative consequences for human physical health, with links to cancer, diabetes, ▶



Yet when lighting levels are cut, as they were in Tucson, Arizona, many don't miss it or even notice

Unlit landmark: Paris now turns off the Eiffel Tower's lights an hour earlier every night



We have the technology to change the way we use light, such as using low-glare streetlights

▶ obesity and other diseases; higher energy costs; and unnecessary carbon emissions.

What's 'wrong' about the way we light is also often an issue of equity, justice and access. Poorer populations seldom have a say about their lighting and are often subjected to harshly lit nighttime environments justified by the (unsupported but widely assumed) idea that more light will mean less crime. The right to experience natural darkness is enjoyed by fewer and fewer people.

Bringing back the stars

The good news is that we can have the light we need, while still reducing these costs. A few examples: DarkSky International has worked successfully with various industries, from oil and gas to sports lighting, to lower their levels of light. Communities all over the world have created lighting ordinances to save money and cut carbon emissions. In France, for example, many localities turn off their streetlights after midnight (as Paris does with the Eiffel Tower).

DarkSky International's 'Five Principles for Responsible Outdoor Lighting' guidance offers an easy summary of the ways we can still have light but reduce overuse and misuse. In addition, LED technology offers the revolutionary opportunity for innovative lighting controls. We know how to light the 'right' way, and to do so is a win–win–win–win situation: reducing threats to our health, cutting costs, bringing back the stars and improving our safety. As Hartley tells me, "if we could do it all over again, we'd probably do it differently".

And so, if indeed there is something wrong with the way we use light at night, and we have the technology to change, why don't we? For one thing, lighting decisions are seldom made by lighting designers (let alone by astronomers, physicians or wildlife biologists). Instead, decisions are too often made based on recommendations from those who benefit from selling more light.

And, ironically, most decisions about night lighting are made during the day. A good example of this on a domestic level is the way that people often purchase new lights based on what the lighting fixture will look like during daylight hours, rather than what the light will look like at night when they are fast asleep inside their homes.

Perhaps most importantly, as we have moved from oil lamps to gas lamps to electric lighting and now to electronic solid-state lighting, our ability to

ANSHAR73/GETTY, ANA-O/GETTY, IMAGODENS/GETTY, GEORGIA MACMILLAN

◀ Visitors to Venice enjoy the atmosphere created by low lighting in the streets and canals at night

produce more and more light has grown, but our thinking about light hasn't.

Ruskin Hartley told me about visiting a nearby store to find, "on the closeout clearance rack a 5,000-lumen fixture that you can put up and blast light wherever you want. And what's happened over the last generation, accelerating over the last 10 years with a 10 per cent growth in light pollution, is light has become so cheap, so ubiquitous, and we can just spray it everywhere."

See the light, value the dark

To reverse the costs of light pollution, then, we need to change the way people see light. One reason for optimism is that when people see good lighting, they appreciate it. Fabio Falchi cites how, "Venice is lit using lower levels of light to create a beautiful nocturnal atmosphere. If you can show people this kind of example," he says, "they see it immediately."

Hartley adds that "people in Britain really value their landscapes. They value their national parks. They're proud of these historic and living landscapes and they want to protect them. But we have to extend those protections into what's happening at night."

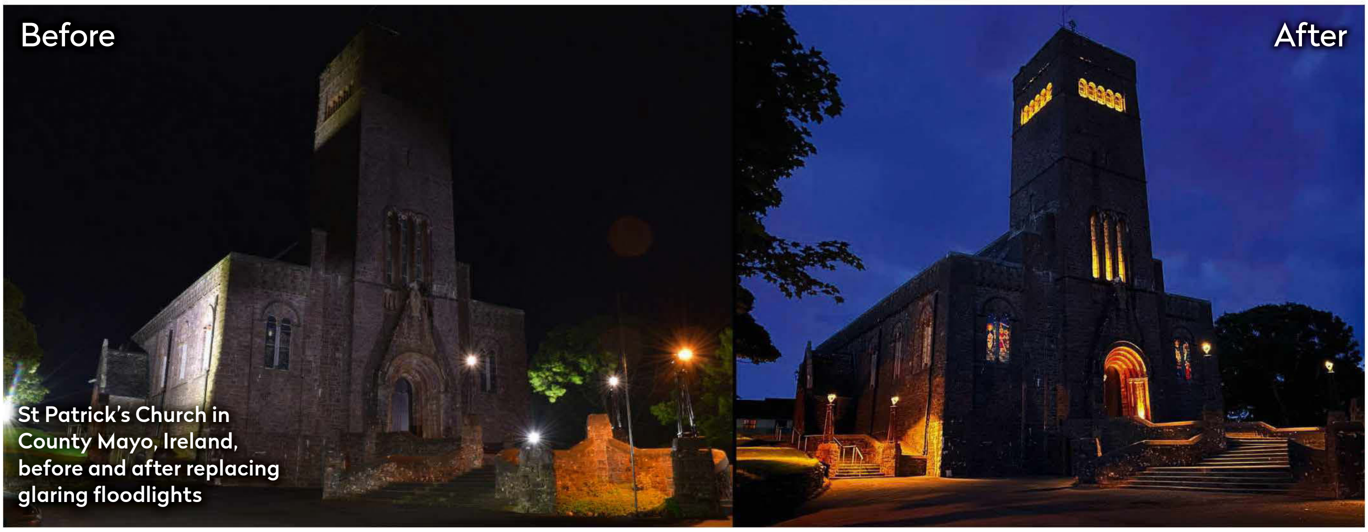
> "One reason for optimism is that when people see good lighting, they appreciate it"

In other words, once people see the night as part of the landscape they love, they will start to see – and object to – the overused and misused lights that would disrupt it.

I keep returning to those images from the *World Atlas of the Artificial Night Sky Brightness*. Most of us, walking outside tonight, wouldn't notice a change in the lighting from the night before. But if we could go back 50 or 75 years, we would be stunned. It's a little like the experience of being awed by a natural dark night sky and then returning to whatever light-polluted city or suburb you call home and realising that most of the people around you have no idea what they're missing, let alone any idea of the many costs from our overuse and misuse of light.

Is there something wrong with the way we use light at night? Without a doubt. But we have everything we need to turn this problem around. The question is not 'light or no light', but what kind of light, where and when. Finding the right answers to those questions starts with seeing the light already around us.

Paul Bogard is the author of *The End of Night: Searching for Natural Darkness in an Age of Artificial Light*



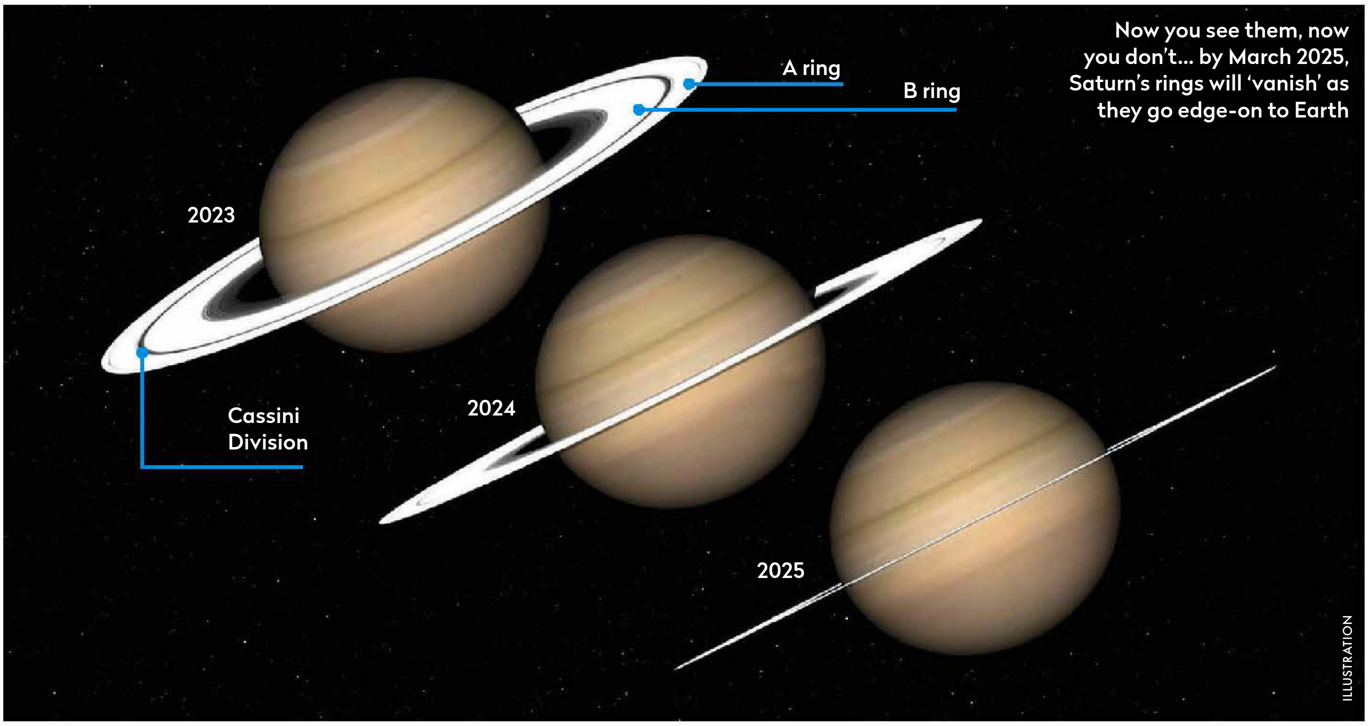
St Patrick's Church in County Mayo, Ireland, before and after replacing glaring floodlights

The fundamentals of astronomy for beginners

EXPLAINER

Saturn's vanishing rings

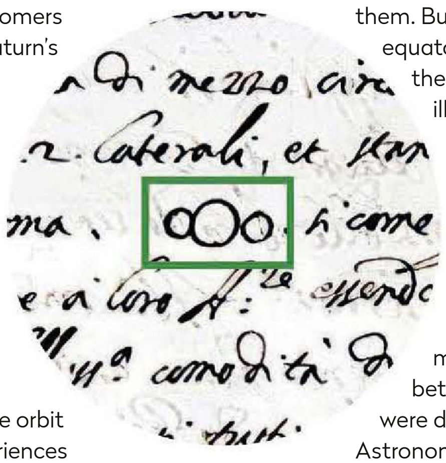
What you should know about the planet's iconic hoops before they disappear this month



Now you see them, now you don't... by March 2025, Saturn's rings will 'vanish' as they go edge-on to Earth

Over the past few months, astronomers have been keeping an eye on Saturn's rings as they slowly disappear. This month, on 23 March, they will finally appear to vanish from view. Don't worry, their disappearance is only temporary as they'll be returning just a few months later. When Saturn's rings vanish like this, astronomers call the event a ring plane crossing and it's all down to how we view Saturn from Earth.

Lying at an average distance of 1.43 billion kilometres (886 million miles) from the Sun, Saturn takes 29.4 Earth years to complete one orbit of our star, and as it does so, the planet experiences seasons and solstices due to its axis of rotation being tilted by 26.7°. Earth is also tilted in its orbit, by 23.5°, and as both planets travel around the Sun in their own orbits, the way we see Saturn's rings from Earth slowly changes. Sometimes we see them from above and sometimes from below, the Sun illuminating them. But when the Sun shines directly over Saturn's equator during the Saturnian equinox, we see the planet and its rings edge-on, creating the illusion of the rings 'disappearing'.


di mezzo a
laterali, et stan
ma . OOO . ci come
e a loro A:^{te} essendo
n.° comodità di
tutti

▲ **To Galileo, the rings appeared as two 'ears' on either side of the planet**

Rare opportunity

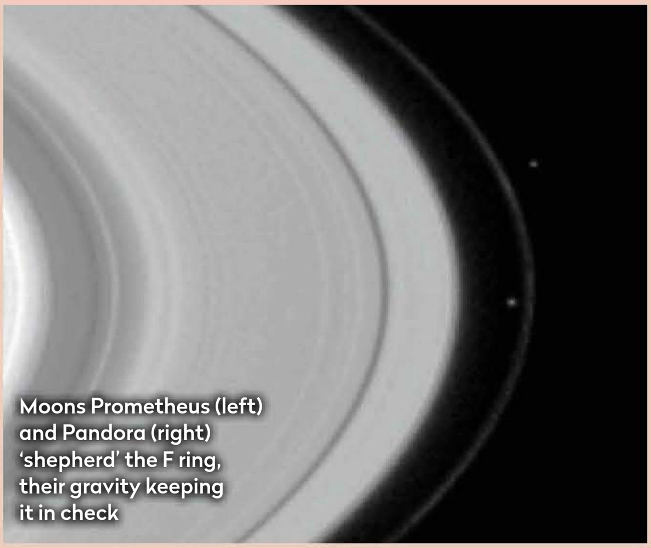
Ring plane crossing events are fairly rare, occurring around every 15 years. While the bright, highly reflective rings are temporarily out of the way, they provide a great opportunity for astronomers to make new discoveries. According to NASA, between 1655 and 1980, 13 moons of Saturn were discovered during ring plane crossings. Astronomers also grab the chance to study the orbital motion of the planet's moons and observe transits, occultations and even eclipses.

Saturn is one of the most distinctive planets in the Solar System. Composed mainly of hydrogen and helium, it is the second-largest planet, with a whopping diameter of 116,500km (72,400 miles).

NASA, NASA/JPL/SPACE SCIENCE INSTITUTE X 3

Keeping the rings in shape

Saturn's moons help to guide and form the planet's alluring rings



Moons Prometheus (left) and Pandora (right) 'shepherd' the F ring, their gravity keeping it in check

The moons of Saturn play an important role in shaping the planet's rings. Its inner moons sculpt the rings by creating sharp edges and gaps in between them, and have come to be known as shepherd moons. For example, Prometheus and Pandora keep the F ring in shape through their gravitational forces, while Pan orbits within the Encke Gap and Enceladus contributes material to the E ring by venting icy particles.

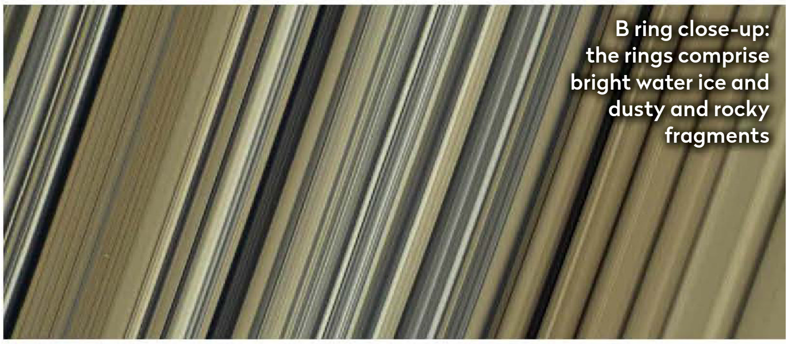
Saturn has almost 150 known moons with confirmed orbits, which range in size from thousands of kilometres (Titan, Saturn's largest moon, is bigger than the planet Mercury!) down to a couple of hundred. These moons may have formed from collisions with other moons, the gradual clumping together of icy material or even from the Solar System's protoplanetary disc. But the current total is not fixed and we don't know how many moons there actually are. There's an unknown number of objects with their own orbits in the rings themselves, including microscopic particles and moonlets, not to mention distant as-yet-unidentified moons.

Its beautiful ring system makes the planet unique and was first observed by astronomer Galileo in 1610, when he reported what through his early telescope looked like ears or handles on the planet. It wasn't until almost 50 years later that Christiaan Huygens discovered that the 'projections' Galileo had seen on Saturn were in fact a ring. Twenty years later, Giovanni Cassini identified more than one ring and spotted gaps between them.

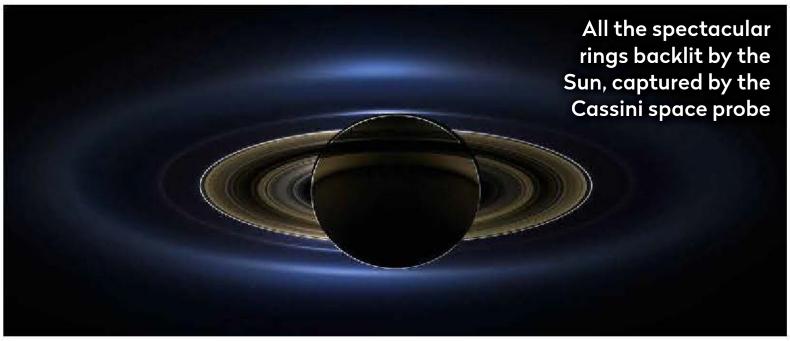
The two brightest rings that he could see are named A and B, and the huge 4,800km (3,000-mile) gap separating them is named the Cassini Division in honour of his discoveries. Today, we know that there are seven main rings, A to G, each 'new' ring being designated with a letter as it was discovered. The G ring, located between the E and F rings, is the most recent ring discovery. It was found in 1980 by Voyager 1 as the spacecraft flew by.

Saturn's rings are complex, separated by subdivisions, gaps and ringlets. They are spread over 282,000km (175,200 miles) and almost entirely composed of particles of water ice ranging in size from tiny grains to boulders tens of metres in diameter. The rings are surprisingly thin – only around 1km (0.6 miles) in thickness.

The series of thin rings that make up the ring system once contained high-energy particles that were highly inclined in their orbits, which collided with other particles. As these collisions slowed down or stopped, the particles would move to lower-energy orbits and over time flattened into thin, flat discs surrounding the planet. A recent study has suggested that Saturn's rings are not as ancient as astronomers once originally thought, but instead may be no more than 400 million years old.



B ring close-up: the rings comprise bright water ice and dusty and rocky fragments



All the spectacular rings backlit by the Sun, captured by the Cassini space probe

Katrin Raynor is an astronomy writer, communicator and longtime lunar observer

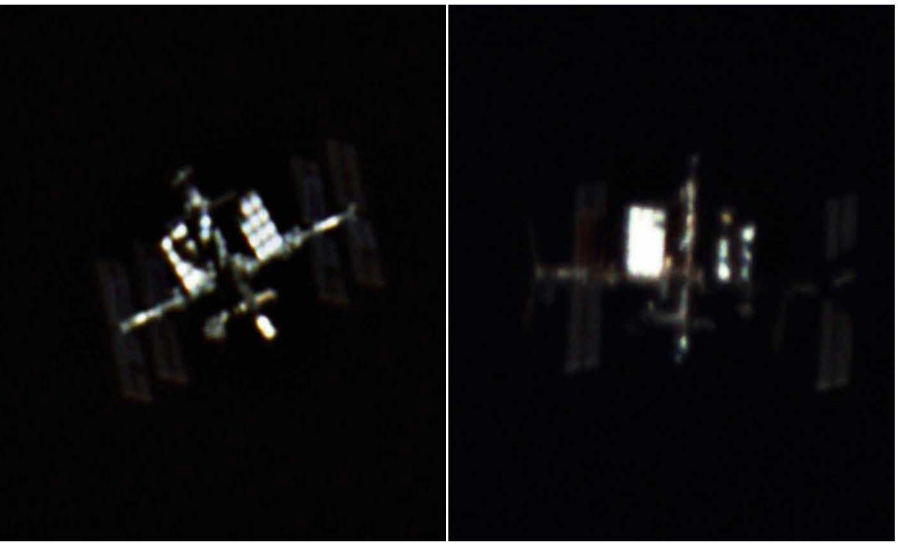
Unfortunately, Saturn isn't well placed during the March 2025 ring plane crossing and will be too close to the Sun for us to observe the complete disappearance either from Earth or with telescopes in space. It doesn't emerge from the Sun's glare again until late April, in the early morning twilight. The planet will be further from the Sun in its orbit and much better placed for the whole of the next ring plane crossing, but that's not until 2038. So it's just as well that, as astronomers predict, Saturn won't lose its rings forever for another 300 million years!

Practical astronomy know-how for every level of expertise

SKILLS FOR STARGAZERS

How to photograph the ISS

Tips for capturing a shot of the International Space Station next time it passes overhead



▲ **Ivana's shots of the ISS passing over her Brighton home in 2024 and 2023, taken with a Celestron CPC800 (left) and CPC925 (right), and a ZWO ASI662MC**

If you've ever spotted the International Space Station (ISS) streak across the sky, you may have wondered how it's possible to photograph something that moves like a fast, bright star at the speed of 28,000km/h (17,500mph) in low Earth orbit. However, with a mid-sized telescope and some patience, you'd be surprised how straightforward it can be to manually capture this iconic spacecraft from your garden.

If you live below 51° latitude north or south, the ISS will be visible overhead in phases for a few days straight and is most visible at dusk or dawn, when it reflects sunlight. For budding imagers, the best time to capture it is when the flyover is as high in the sky as possible, ideally 70° and above. When it's low on the horizon, you will be battling layers of atmospheric distortion. For more details on how to see the station, head to page 40.

To receive alerts on only the best visible passes and timings, you can subscribe to NASA's Spot the Station website (https://spotthestation.nasa.gov), which will send an email ahead of time with coordinates, exact times and the height of the pass for your location. The free weather app Clear Outside (www.clearoutside.com) also shows ISS passes above any location, as well as the apparent magnitude of each pass.

ALL PICTURES: IVANA PERANIC

Ivana Peranic is a cellist by day and an astrophotographer by night, based in Brighton, UK

A medium-sized telescope (at least 5 inches) is a necessity, as the ISS requires good focal length to resolve any details. For tracking the ISS manually, the optical tube needs to be mounted on a sturdy altaz mount where both clutches can be released and the tube pushed freely in both directions. A good-quality and well-adjusted finderscope is essential, as you'll use this for the actual visual tracking, with either a crosshair or a red dot to clearly mark the centre of the field of view.

While it's possible to use a DSLR camera, it will be limited by the speed of its continuous shutter, making it difficult to time and achieve sharp images. An ideal camera would be a dedicated planetary or guide camera, as they can be left to shoot continuously at a very high speed. You can use a free capture program such as SharpCap or FireCapture to manage your image-capture settings. Settings will vary according to your equipment and the magnitude of the pass, but a good starting point is to set your gain to around 60–70 per cent of the slider and use exposures of less than 1 millisecond. It may need adjusting after the first snaps – trial and error will reveal the best settings for your equipment.

Before the pass, get everything ready; ensure your camera is well focused and adjust your finderscope carefully so that the centre of the crosshair or red dot corresponds to the centre of your camera capture screen. It's a good idea to ensure it's properly aligned in the daytime.

When you spot the ISS rising, set your camera to shoot, follow it in the finderscope and try to let it pass as many times through the centre as possible to ensure it's caught in your camera video.

What you'll need

- ▶ An app or website that predicts favourable ISS passes, such as Spot the Station or Clear Outside
- ▶ Medium-sized home telescope, ideally 5–6 inches or larger
- ▶ Altaz mount that can be pushed manually in all directions
- ▶ 30–50mm crosshair or red dot finderscope, meticulously adjusted
- ▶ Fast planetary or guide camera with an in-built or after-market UV/IR cut filter
- ▶ Capture software, such as SharpCap or FireCapture
- ▶ Software to extract the frames with the ISS, such as AutoStakkert!

Step by step

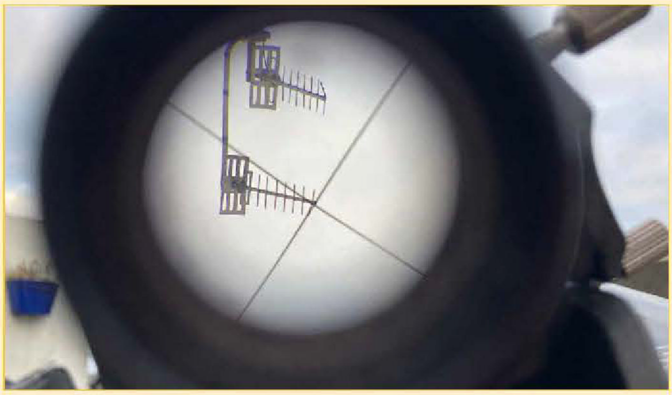
NASA
Sig
Spot The Station
International Space Station

Step 1

Sign up for customised alerts at https://spotthestation.nasa.gov and choose an ISS pass of 70° or more in height. Before the ISS pass is due, visualise where it will be rising from in the sky, based on the coordinates provided for your location.

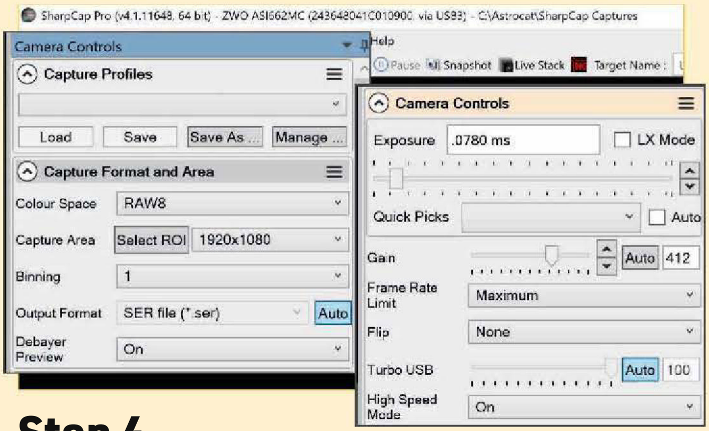
Step 2

Prepare your telescope and camera, so that you're ready in good time for the flyover. Open your capture software (such as SharpCap or FireCapture) and focus on the Moon or a bright star. If focusing on a star, it is easiest done by using a Bahtinov mask.



Step 3

Adjust your finderscope so the centre of its field of view matches your camera capture screen. Ideally do this in daylight, using a distant object like an antenna or chimney. When it's time to shoot, release your mount's clutches and push the telescope freely.



SharpCap Pro (v4.1.11648, 64 bit) - ZWO ASI662MC (243648041C010900, via USB3) - C:\Astrocat\SharpCap Captures

Camera Controls

Capture Profiles

Capture Format and Area
Colour Space: RAW8
Capture Area: 1920x1080
Binning: 1
Output Format: SER file (*.ser)
Debayer Preview: On

Camera Controls
Exposure: .0780 ms
☐ LX Mode
☐ Auto
Gain: 412
Frame Rate Limit: Maximum
Flip: None
Turbo USB: 100
High Speed Mode: On

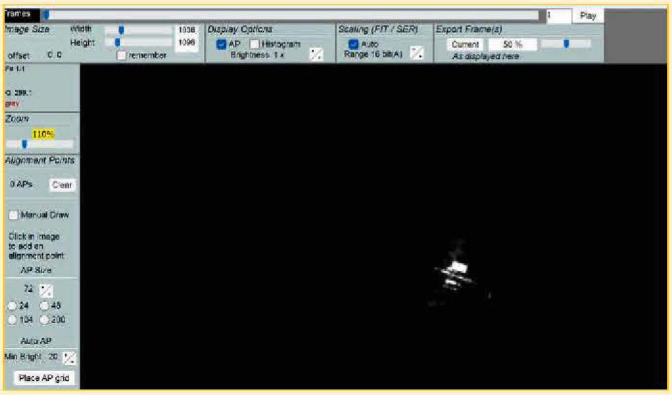
Help
Pause
Snapshot
Live Stack
Target Name :
Load
Save
Save As ...
Manage ...
Select ROI
Auto
Quick Picks
Auto
Auto

Step 4

While the optimum settings will vary from camera to camera, you can try the settings above as a starting point. When you see the ISS rising, set your camera to capture unlimited frames or shoot continuously, then push your telescope to track it.

Step 5

Follow the ISS visually in the finderscope and let it pass through the centre of the crosshair or red dot as many times as possible while the telescope is still. Trying to keep the ISS in the centre while moving the telescope continuously may result in a blur!


Play
Image Size
Display Options
Scaling (FIT / SER)
Export Frame(s)
Zoom
110%
Alignment Points
Clear
Manual Draw
Place AP grid

Step 6

Run your capture through a program that extracts all the frames with the ISS in, such as PIPP, or find and extract them in a program such as AutoStakkert! Frames captured close together can be stacked to reduce noise and increase detail.

Take the perfect astrophoto with our step-by-step guide

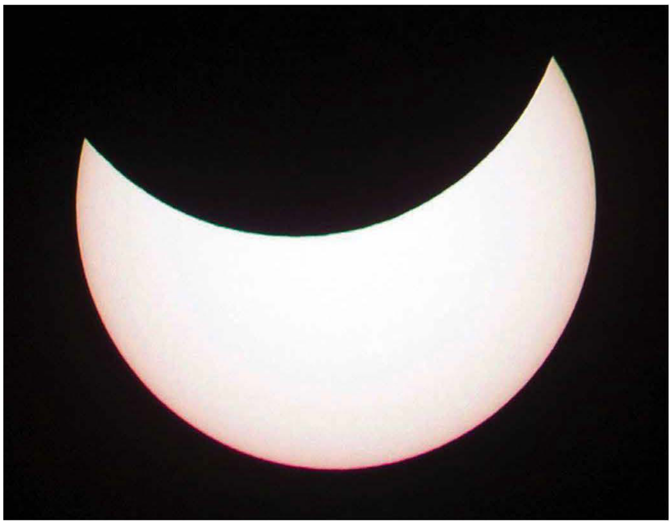
ASTROPHOTOGRAPHY CAPTURE

CAUTION
Don't look at the Sun directly with the naked eye or any unfiltered optical instruments

Shoot the partial solar eclipse

Read our tips so you're ready to capture the moment the Moon covers the Sun on 29 March

Solar eclipses visible from the UK are relatively infrequent events. Add in our extremely unpredictable weather and you could almost class seeing one as quite a rare occurrence. Let's hope the weather is kind for the partial solar eclipse happening on 29 March, as a fairly decent amount of the Sun's disc will be covered by the Moon. You can find out more information about the eclipse on page 46, but here we're going to concentrate on how to record the event photographically.



▲ **A 'bite out of the cookie' photo of a partial solar eclipse. Right now, the Sun is at its most active, so you may be able to capture sunspots and prominences in your images**

While a partial isn't a patch on a total solar eclipse, there's plenty to focus on that can elevate a partial eclipse photographically. For the 29 March event, there's another important factor to take on board, that we're at the predicted peak of Solar Cycle 25. This means there's a likelihood that sunspots will be visible on the Sun's surface, its photosphere. Also, for those with hydrogen-alpha filters, there's a good chance that plenty of chromospheric detail will be on view, as well as a number of prominences.

Extra drama in store

Although we can't accurately predict how many prominences will appear and where they'll be, or indeed whether there will be any at all, the very fact that we're at solar maximum means there's a heightened probability of seeing some solar action. Photographically, this is important.

Images of the partially eclipsed Sun during solar minimum, when there is little or no activity happening, generally simply look like a bright circle with a bite taken out of it. With sunspots and prominences available, the scene takes on a new level of interest and, given steady conditions, can be used to produce some very dramatic images indeed.

Best of all, if you're used to imaging the Sun when there's no eclipse taking place, there's very little you need to do to adjust your working method. For high-frame-rate captures, whether in white light, hydrogen-alpha or through another type of narrowband solar filter, the biggest concern is capture time. Take too long and the edge of the Moon may appear blurred due to its apparent motion across the Sun's disc.

And what if you don't have expensive kit? Well, if you have the means to take a photograph, say using a smartphone, there are still ways you can capture the eclipse. By using the principle of pinhole projection, it's possible to create a miniature version of the eclipse using nothing more than a couple of bits of card. Of course, you don't need to stop at a single projection hole either. Why not apply your full creativity to recording the event in an unusual and potentially unique manner?

Smart scopes that function as imaging devices are now popular and many come with solar filters that can be slipped into position to allow the scope to safely view and image the Sun. With so many different options available, there's a method for recording the upcoming partial solar eclipse that should suit anyone. Just keep your fingers crossed for decent weather!

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

Equipment: telescope, camera or smartphone, solar filter, card, colander, tea strainer or similar

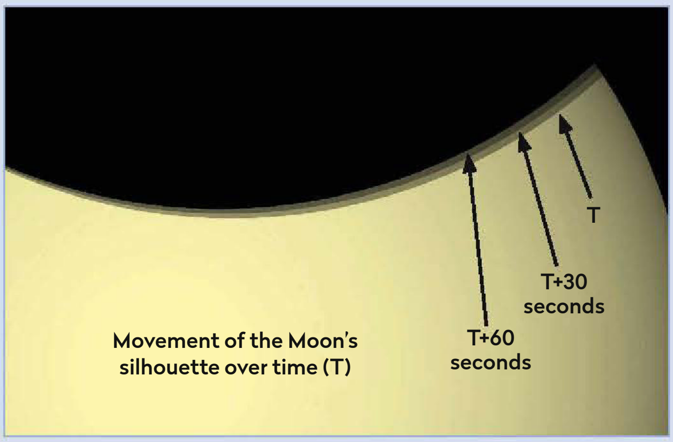
✉ **Send your images to:**
gallery@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

Step by step

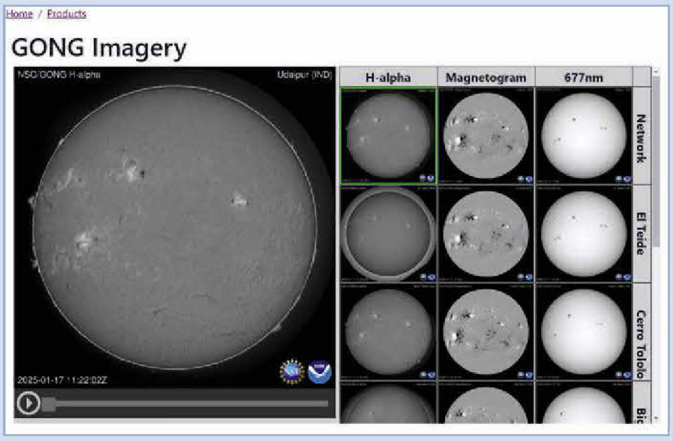
STEP 1

If you're using a telescope to observe the partial solar eclipse, a full-aperture certified white-light solar filter can reduce the Sun's light to a safe level for imaging. A short-focal-length scope will allow you to see all, or a decent portion, of the Sun's disc in one view. If you have one, a mono camera works best, especially if it's fitted with a green or red filter.



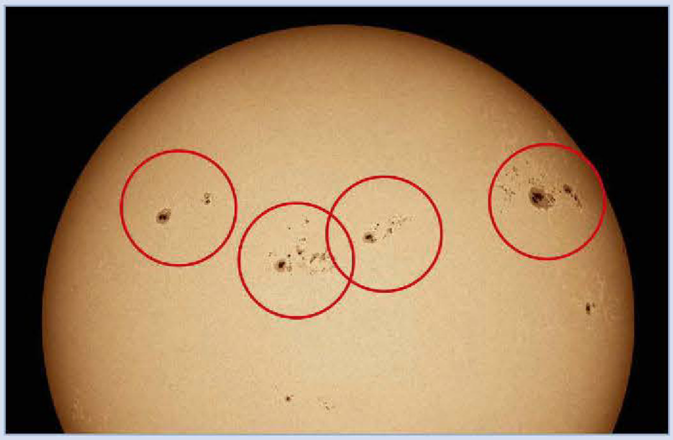
STEP 2

Take short sequences to avoid motion blur on the Moon's edge; how long depends on focal length used, but try 5–10 seconds. Or, if using a DSLR or similar, take single frames. If seeing conditions are poor, stacked high-frame-rate sequences will be sharper, but you can stack single frames too. Avoid over-exposure.



STEP 3

If using a narrowband filter, eg for hydrogen-alpha imaging, set up as you would normally. Identify cardinal directions. Sites like **https://gong2.nso.edu** provide near real-time images orientated with north up, east to the left. Consider whether any solar prominences may be hidden over the course of the eclipse.



STEP 4

Plan how you want the final image sequence to pan out and how many captures or stills to take. Avoid unrealistic sequences that tie you to your camera. Instead, identify interesting positions of the Moon relative to features on or around the Sun's disc and focus on capturing shots when the Moon's edge is near those.

STEP 5

Make pinhole images using a tea strainer or a 1–2mm hole in a piece of card to project an image of the Sun onto white paper. Increase the distance between the hole and the screen to make the projected Sun bigger. A smartphone can capture the changes as the eclipse progresses. There's a chance to be creative here!

STEP 6

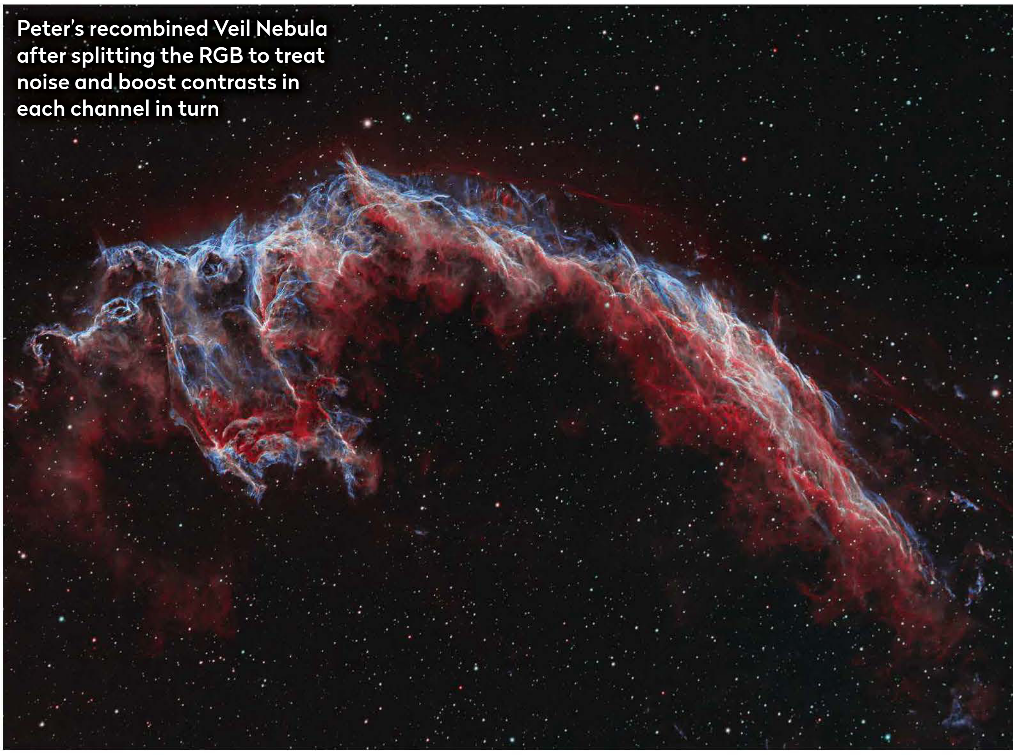
Many smart scopes come with a solar filter. This must be manually applied before pointing the device at the Sun. You can then centre the Sun and watch or image the eclipse via your phone. As well as taking still captures, you could capture film or, perhaps more watchable, a timelapse sequence. Make sure that nothing in the foreground will block the view as the eclipse progresses.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY
PROCESSING

How to fine-tune an image's colour palette

Split an RGB image to edit colour channels individually in Photoshop


Peter's recombined Veil Nebula after splitting the RGB to treat noise and boost contrasts in each channel in turn

There are several ways to get colour into an astrophoto. You can use a one-shot colour (OSC) camera, which produces colour in much the same way a DSLR camera does. Or colour can be produced by combining three monochrome images taken through red, green and blue filters. Indeed, all CMOS and CCD colour astro cameras have a monochrome sensor; it's just overlaid with a matrix of tiny red, green and blue filters called a Bayer matrix. Colour images are then processed from this data by the camera's onboard computer.

When it comes to your processing of astro images, splitting a colour image back into its red, green and blue components can be advantageous for many reasons. It allows the individual colour channels to be processed separately so we can be specific about where we'd like to reduce noise or boost contrasts. And with the advent of dual- and tri-band filters, colour cameras can also be used to create images in alternative colour palettes.

Filters are available that allow the narrowband wavelengths of hydrogen-alpha (Ha), doubly ionised oxygen (OIII) and ionised sulphur (SII) to hit the camera sensor. By splitting images produced by these filters and saving each narrowband component separately, it's easy to create images in different colour palettes, such as the popular Hubble palette, where SII, Ha and OIII are used to replace the red, green and blue channels respectively.

There are many ways to split the RGB channels, but here we'll use Photoshop and a colour image of the Veil Nebula (see above).

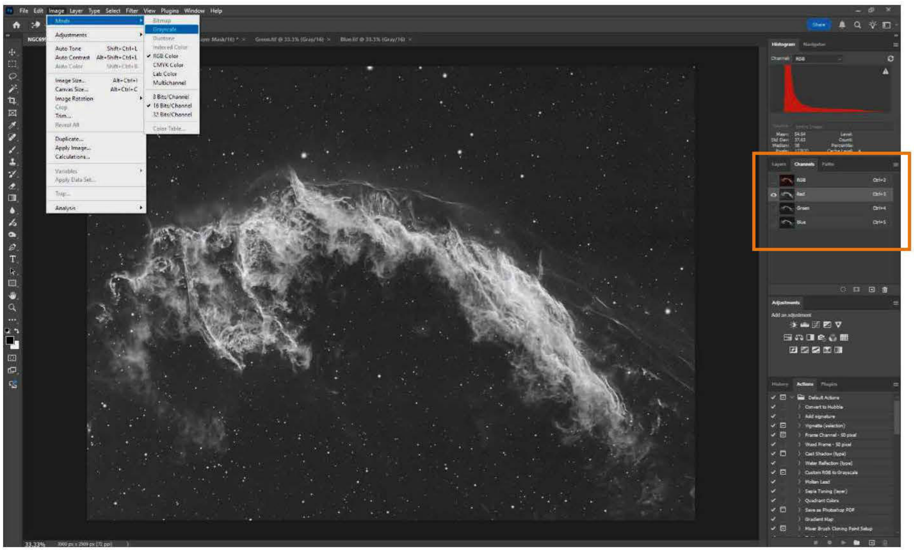
Split the channels

First, open the image in Photoshop. Make sure that you can see the channels tab; if not, switch this on by selecting Window › Channels. Selecting the Channels tab will show all three channels are switched on. Click on the blue and green channels to deselect them, and click the red channel to select it (see Screenshot 1).

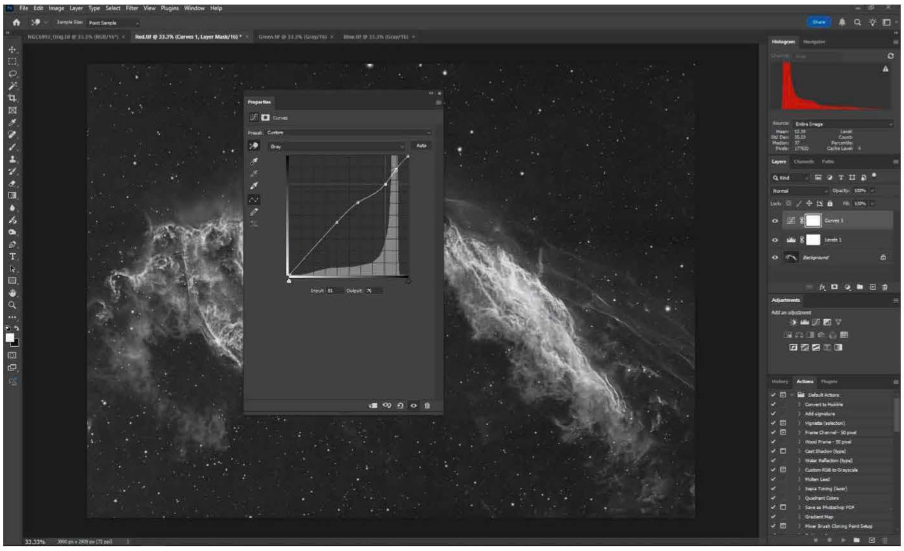
Next, click Image › Mode › Grayscale to change the image from an RGB to a grey image (see Screenshot 1). A message will appear asking if you want to discard the unselected channels. Confirm this by selecting 'OK'. You can now save this as your red channel by clicking File › Save As and naming it 'red channel'.

The next step is to 'undo' the change you made to the original image so that you can save the green and blue channels; this can be done by clicking Edit › Undo. Under the Channels tab, now deselect the red and the blue channels, and select the green channel. Repeat the process

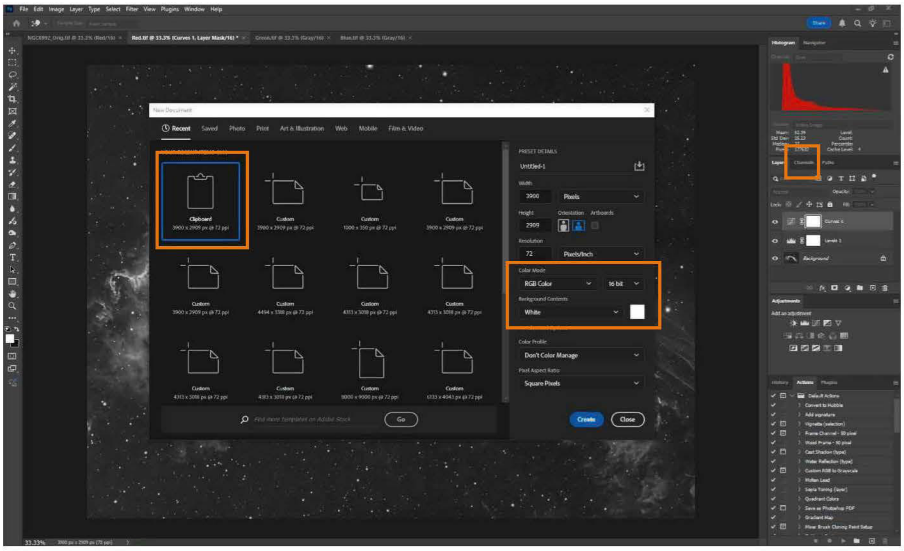
ALL PICTURES: PETER JENKINS



▲ **Screenshot 1: under Channels, click Red. Change image mode to grayscale and discard the other channels. Save this as 'red channel'. Undo and repeat with Green and Blue**



▲ **Screenshot 2: at this stage you can make adjustments to the individual red, green and blue channels using Curves. Use Levels to ensure the black points in each channel match**



▲ **Screenshot 3: open the three RGB images. Select the red and copy all. Create a new blank file and paste into the Red channel. Repeat with green and blue channels, then save**

3 QUICK TIPS

1. Check the black points match between the channels in Levels to prevent any unwanted colour cast.

2. In Grayscale mode, the Curves tool works in the opposite direction to in RGB images.

3. Use the finger symbol in Curves to fix points in place that you don't want to be adjusted.

of changing the mode to grayscale and discarding the other channels, then click File › Save As to save the green channel. Repeat these steps to save the blue channel. You now have three separate files for the red, green and blue channels, as well as your original image, ready for processing.

For my image, when comparing each channel's black points (under Image › Adjustments › Levels), I found that the red channel needed some adjustment to remove the slight red cast I noticed in my initial unprocessed image. Next, I used the Curves menu (Image › Adjustment › Curves) to make adjustments to the red channel to bring out the fainter wisps of the nebula (see Screenshot 2) and to reduce the overall green bias on my green channel file.

Once you've made all your adjustments, it's time to reassemble your RGB image. In Photoshop, ensure your three images are open. With the red channel image selected, select all (Ctrl + A), then copy (Ctrl + C). Next, click File › New. In the dialogue box that appears, select 'Clipboard' as the image type, 'RGB Color' as the colour mode and 'White' as the background (see Screenshot 3).

In your new Untitled image, select Channels and then the red channel. Paste in (Ctrl + V) your red channel image. Repeat this for the other two channels, copying and pasting the green and blue monochromes into their respective channels before clicking File › Save As. Your saved recombined colour image can now be further edited as desired.

Peter Jenkins is an astrophotographer and a fellow of the Royal Astronomical Society

Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

FREE BONUS CONTENT
Find our extended Gallery at www.skyatnightmagazine.com/bonus-content

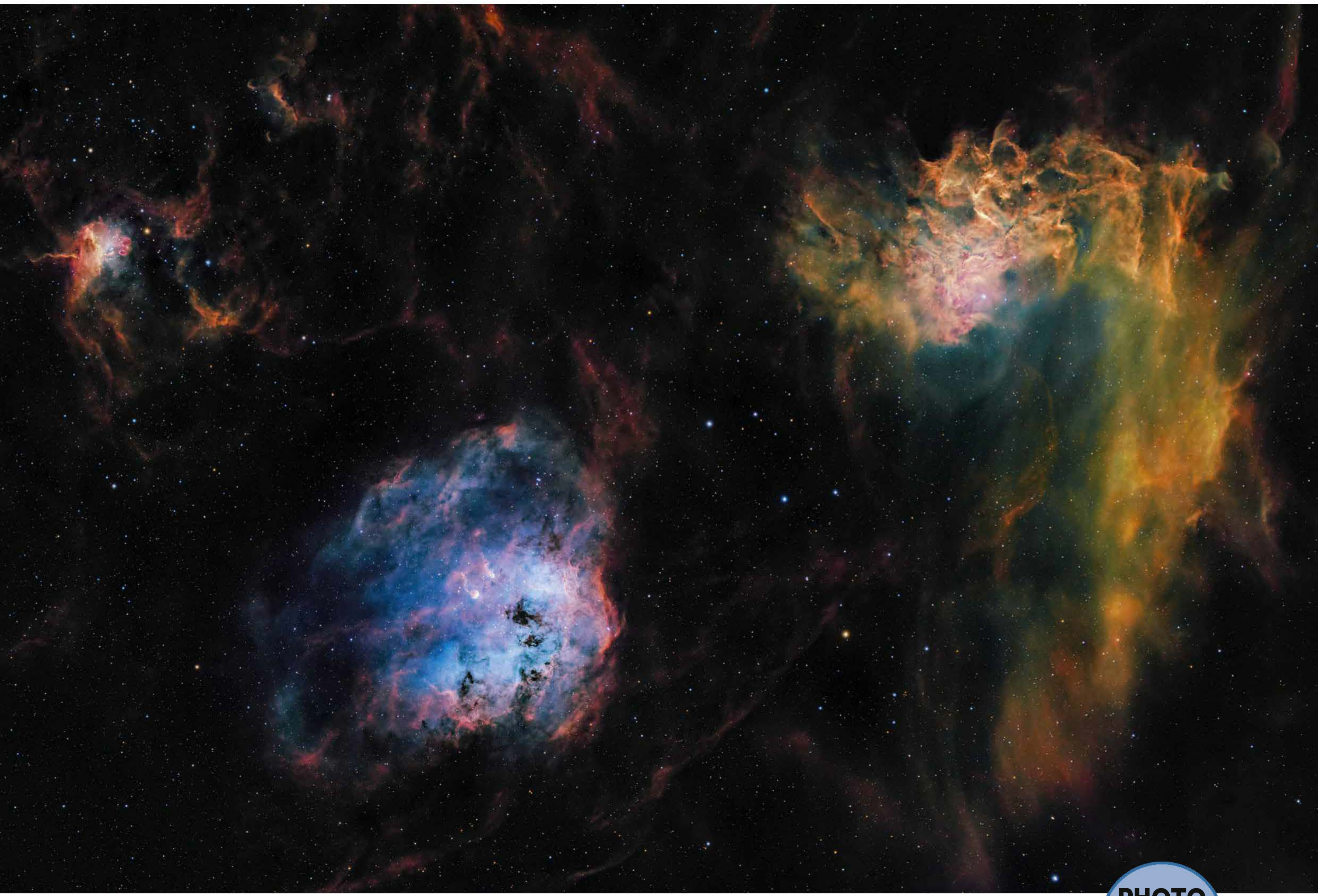


PHOTO OF THE MONTH

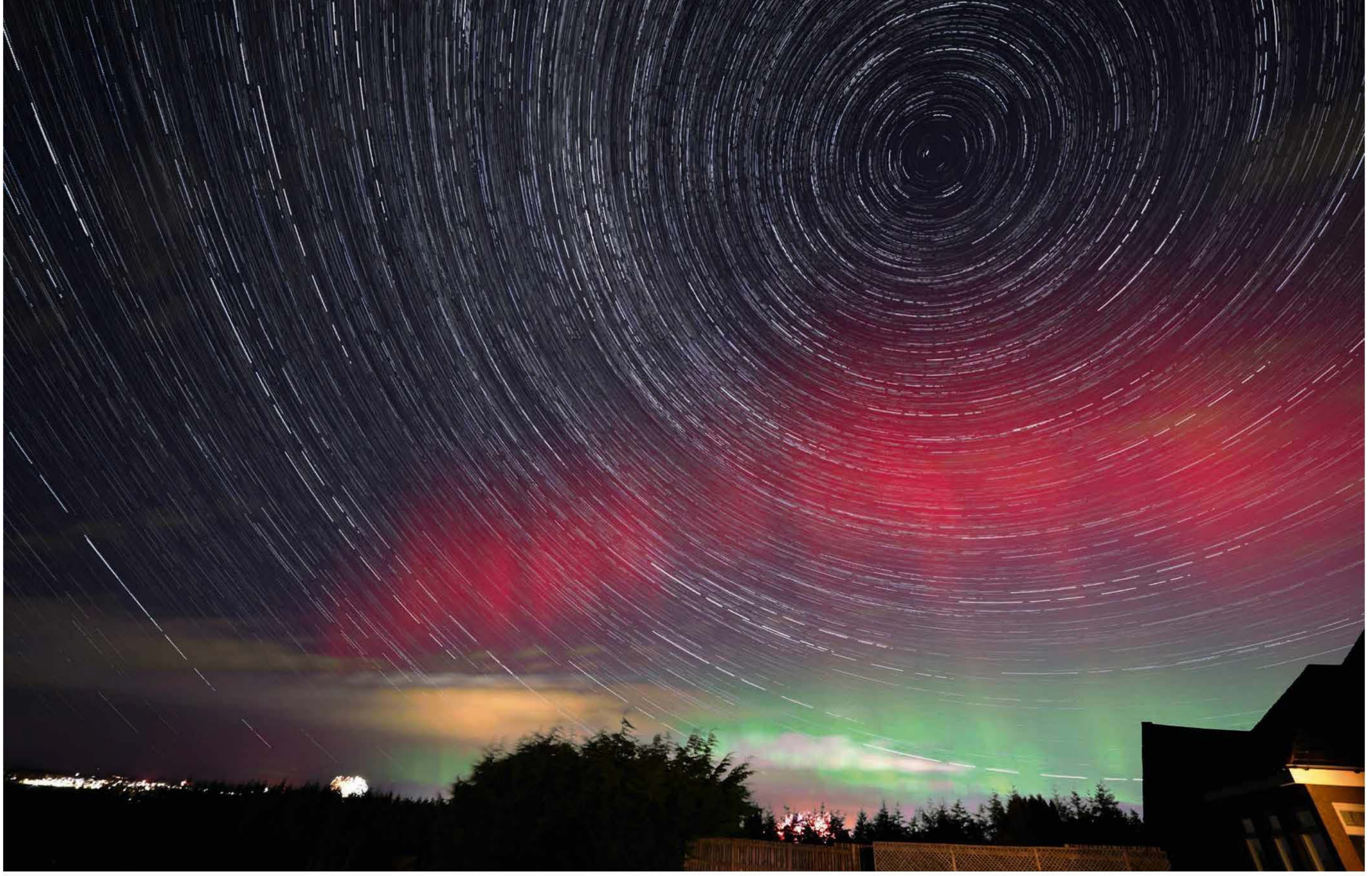
△ The Spider, Tadpole and Flaming Star Nebulae

Andrea Arbizzi, Modena, Italy, 6, 7, 12, 20 and 21 December 2024

Andrea says: "In the constellation of Auriga, we find three wonderful nebulae: the small Spider Nebula (IC 417, on the left), the Tadpole Nebula (IC 410, centre) – the 'tadpoles' being the two central filaments – and the diffuse Flaming Star Nebula (IC 405, on the right)."

Equipment: ZWO ASI2600MC Duo camera, Askar FRA500 refractor, iOptron GEM45 mount
Exposure: Ha and OIII 118x 600", SII and OIII 54x 600", UV/IR cut 80x 30", total 29h 20'
Software: Astro Pixel Processor, PixInsight, Photoshop

Andrea's top tips: "Astrophotography is a challenging hobby with a steep learning curve. I started in 2020 and have learned that it requires patience, money and time! I'd suggest starting with some budget equipment – you can always upgrade later. Remember, not everything will work out the first time, but the more photos you take, the better you learn to manage everything."

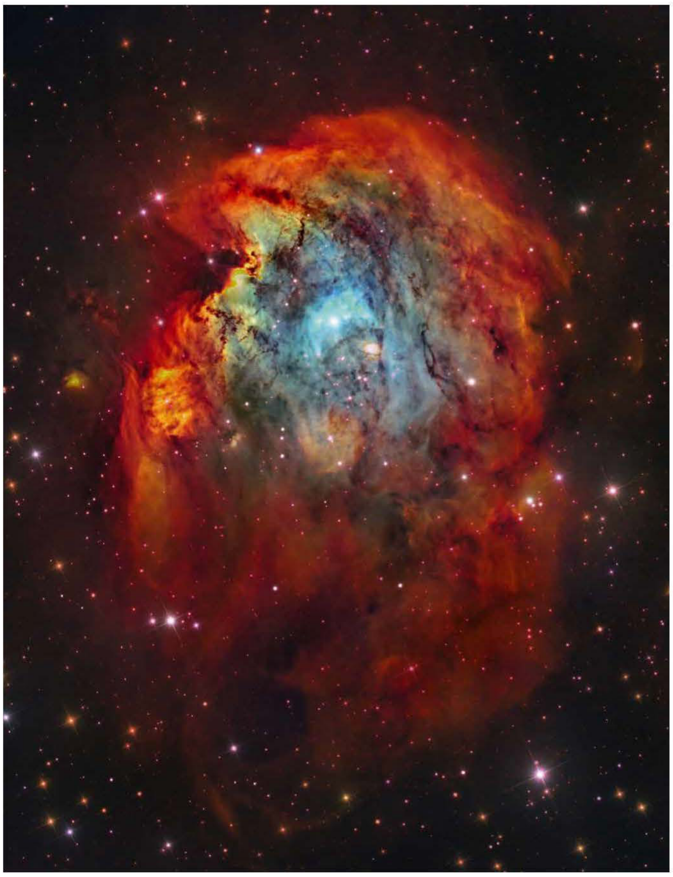


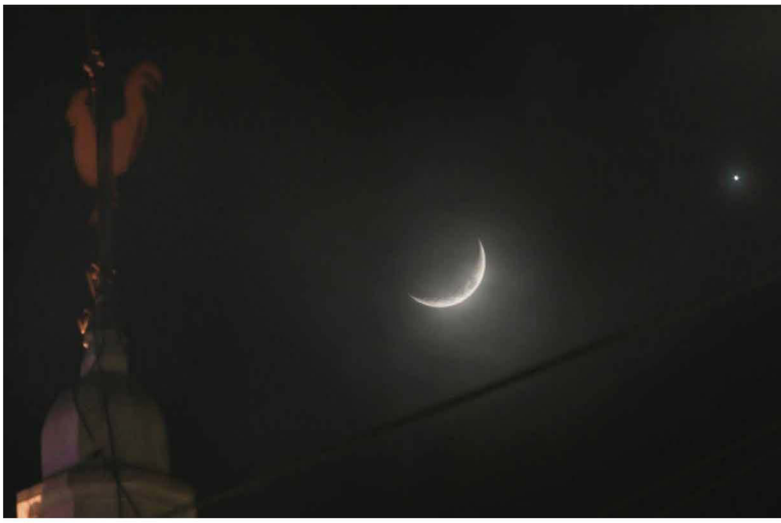
△ Aurora and star trails

Richard Clibborn, Ardoe, Aberdeenshire, 31 December 2024

Richard says: "I spent the final hours of 2024 capturing this image of the northern lights, complete with star trails around the North Celestial Pole… and a few New Year's Eve fireworks at the bottom of the frame!"

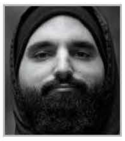
Equipment: Canon EOS R6 Mark II camera, Canon 15–35mm lens, Revue tripod **Exposure:** ISO 800 f/2.8, 161x 15" **Software:** StarStax





△ The Moon and Venus

Rui Santos, Amor, Leiria, Portugal, 3 January 2025



Rui says: "When I saw this conjunction, I grabbed my equipment and managed to frame it against the top of my village's church, despite light pollution, electricity cables and cars passing right by where I was standing."

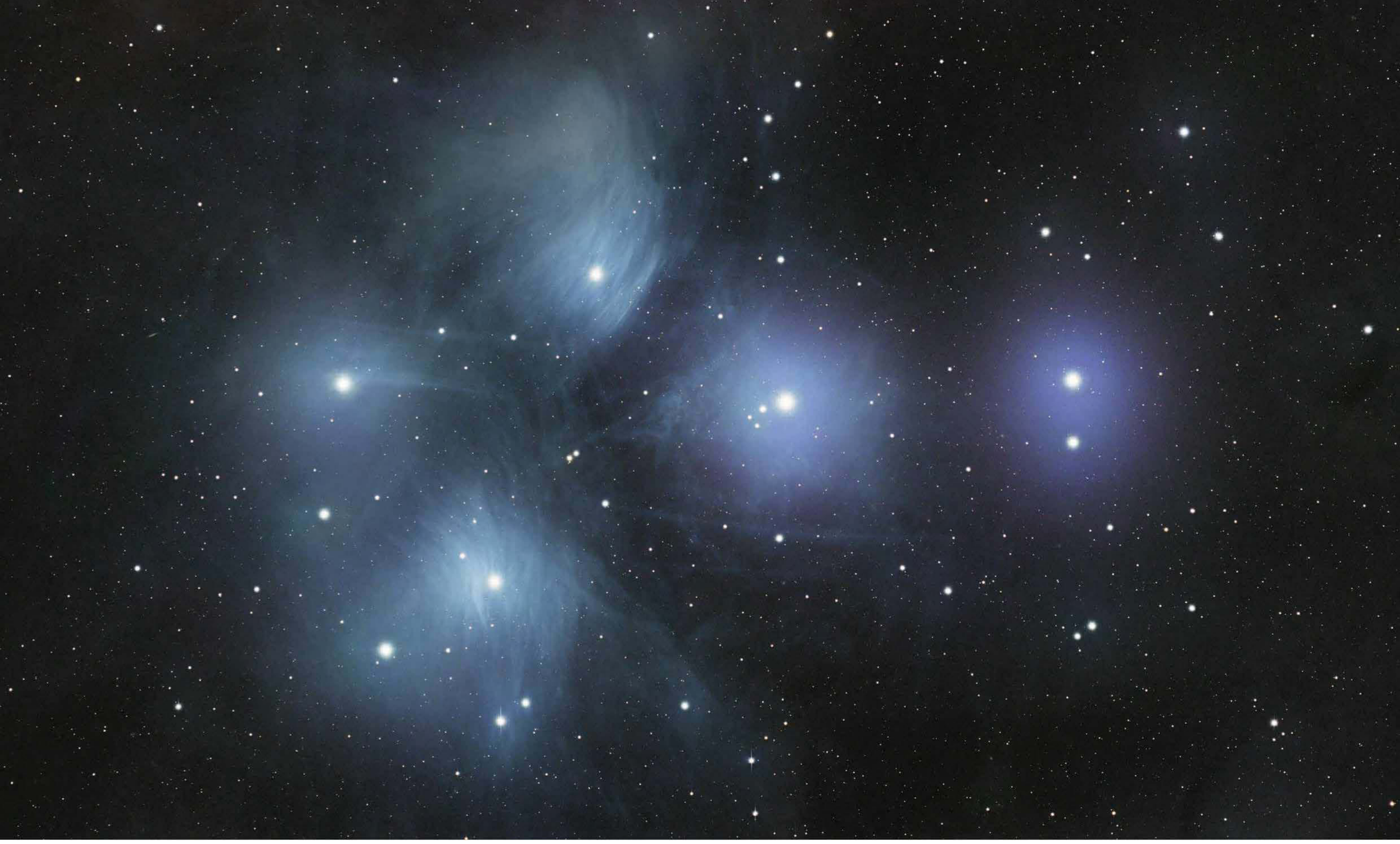
Equipment: Sony α6000 camera, Soligor 75–300mm lens, Geekoto AT24Pro Dreamer tripod **Exposure:** ISO 1,250 f/16, 2.5" **Software:** Photoshop, Lightroom

◁ Open cluster NGC 2175

Emmanuel Delgadillo, Jalisco, Mexico, 25–31 December 2024

Emmanuel says: "I chose this cluster in the Monkey Head Nebula because it's rich in oxygen, hydrogen and sulphur, and has some interesting structures."

Equipment: ZWO ASI6200MM Pro camera, SharpStar SCA260 reflector, Celestron CGE Pro mount **Exposure:** Hα 137x 300", OIII 151x 300", SII 154x 300" **Software:** Astro Pixel Processor, PixInsight



△ The Pleiades

Richard O'Reilly, St Albans, Hertfordshire, 3 January 2025

Richard says: "This was a challenge to capture due to the faintness of the nebulae and the close proximity of the bright star Gamma Cassiopeiae."

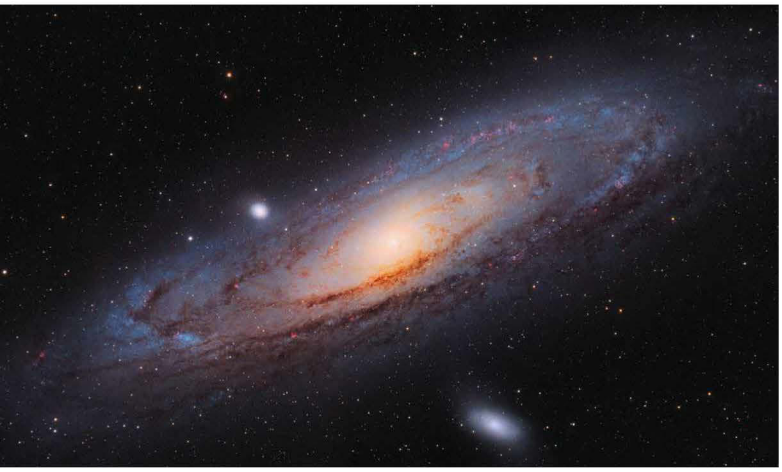
Equipment: ZWO ASI2600MM Pro camera, Sky-Watcher Esprit 120 ED refractor, ZWO AM5 mount **Exposure:** LRGB 30x 120" each **Software:** PixInsight

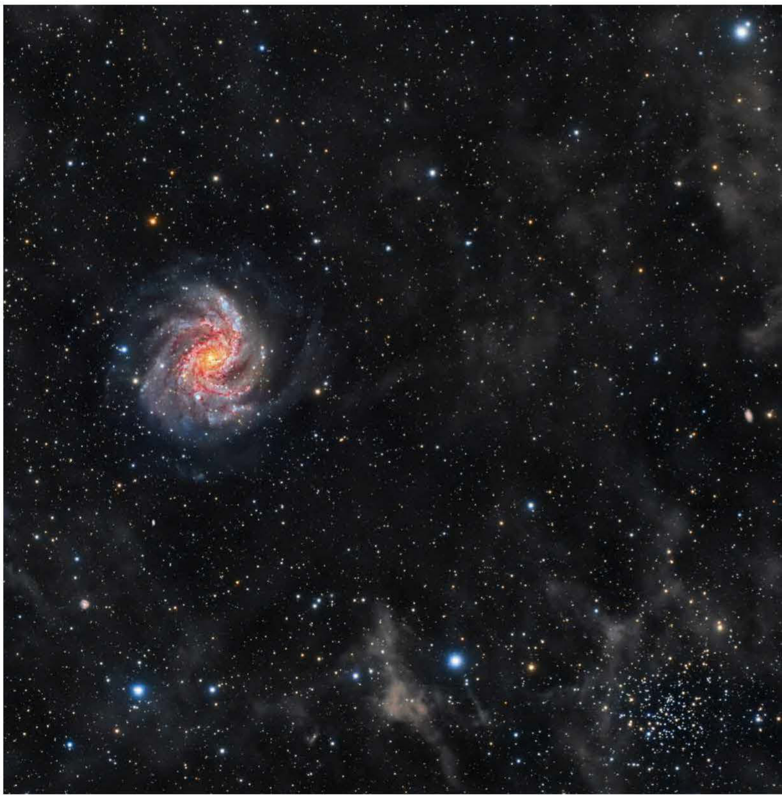
▽ The Andromeda Galaxy

Mark Germani, Vancouver, Canada, October–December 2024

Mark says: "Each year, I image M31 as a gift for my father-in-law. This year's two-panel mosaic was a new challenge, made especially difficult with unusually poor weather."

Equipment: ZWO ASI533MC Pro camera, Astro-Tech AT92 refractor, iOptron CEM26 mount **Exposure:** 544x 90" **Software:** Astro Pixel Processor, PixInsight, Photoshop



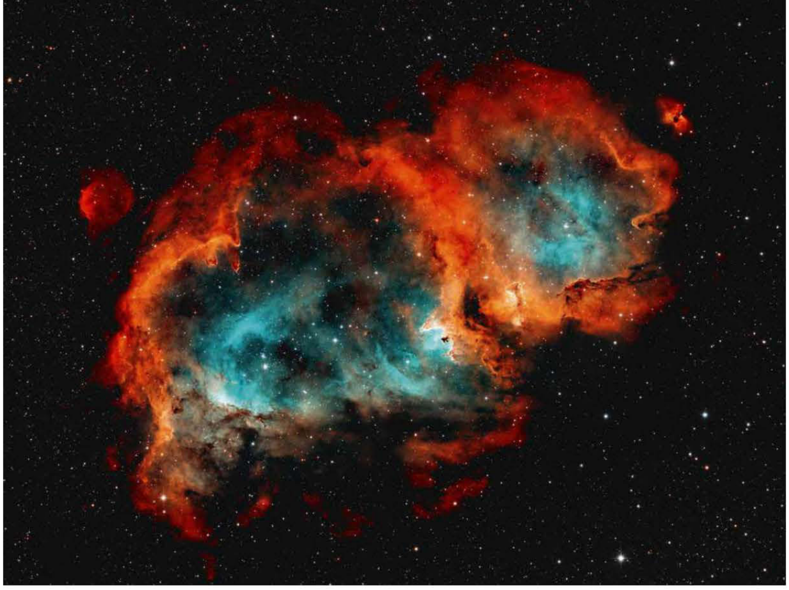


△ The Fireworks Galaxy

Adriano Anfuso, Wëntger, Luxembourg, 13–16 June 2024

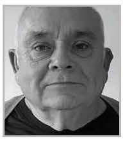
Adriano says: "This image of NGC 6946, the Fireworks Galaxy, was captured over four nights from my back yard. Bortle 3–4 skies allowed me to capture the faint integrated flux nebula surrounding the galaxy."

Equipment: ZWO ASI294MC Pro camera, Askar 107 PHQ refractor, ZWO AM5 mount **Exposure:** 176x 300", total 14h 40' **Software:** PixInsight



◁ The Soul Nebula

Bill Lowry, Chiddingstone Hoath, Kent, 3 October–11 November 2023 and 8 September 2024



Bill says: "This is full of rich colours, especially when shot in narrowband and combined with RGB processing."

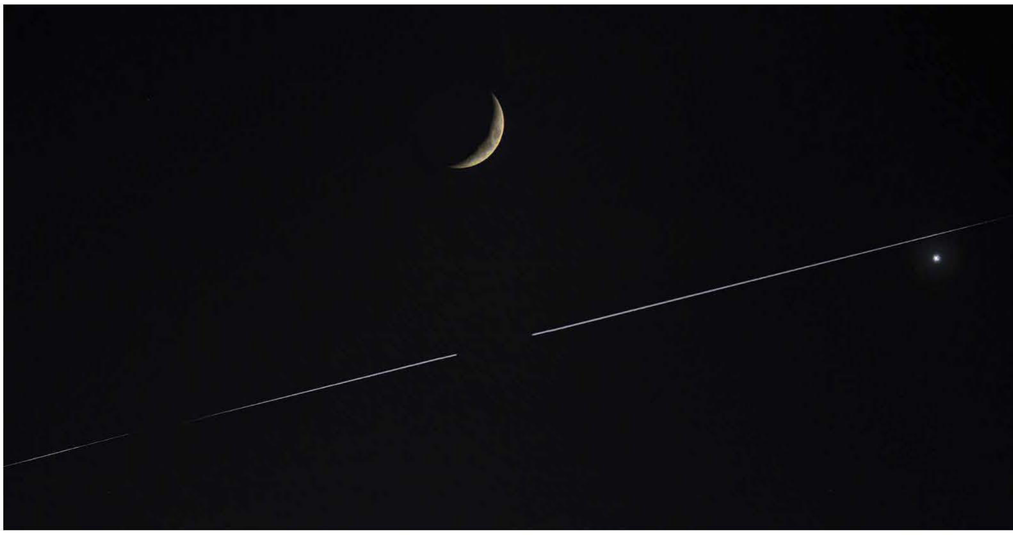
Equipment: ZWO ASI2600MM camera, William Optics GT-71 II and GT-81 IV refractors, Sky-Watcher HEQ5 Pro and EQ6-R Pro mounts
Exposure: total 91h
Software: PixInsight

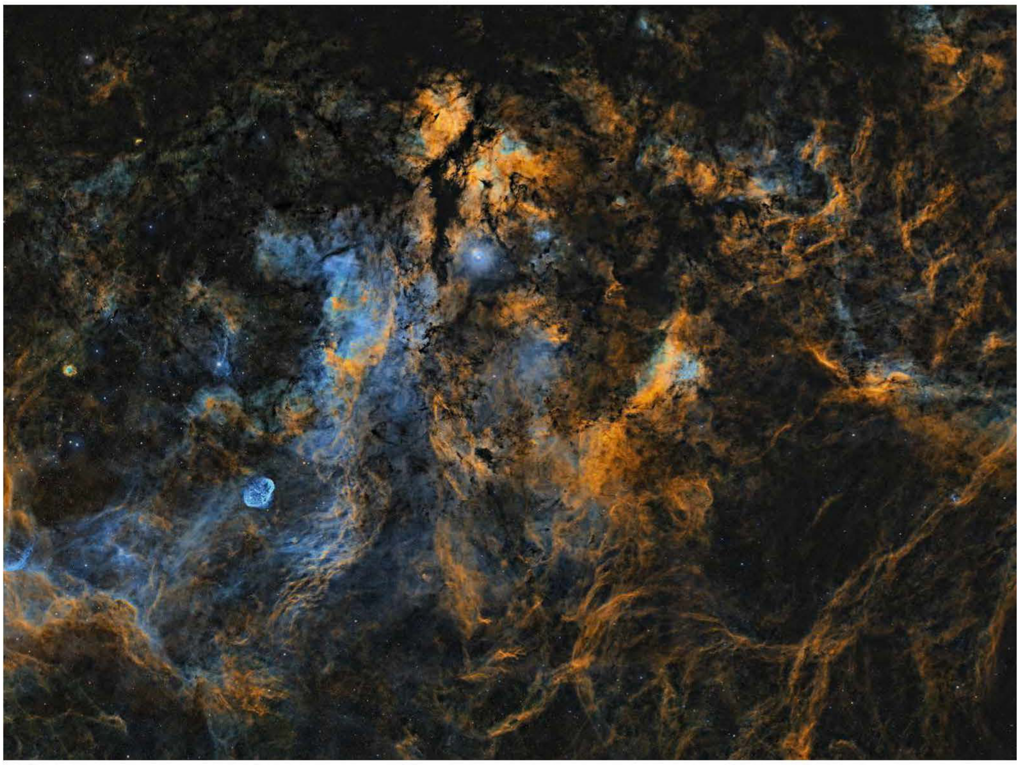
The Moon, Venus and the ISS ▷

Montse Coll, Montcada i Reixac, Catalonia, Spain, 5 December 2024

Montse says: "I knew about the conjunction, but I was surprised to realise, 10 minutes before this picture was taken, that the ISS would be passing very close to Venus. The result was a marvellous transit. I was very happy!"

Equipment: Canon EOS 600D camera, Tamron SP 70–300mm lens, Manfrotto 290 Xtra tripod
Exposure: ISO 200 f/4.7, 3x 10", 2x 5"
Software: Photoshop, Lightroom





◁ The Crescent, Propeller and Soap Bubble Nebulae

Simon Todd, Haywards Heath, 8 July 2023–11 November 2024

Simon says: "After more than 200 hours' imaging across two seasons, I'm thrilled to present this 12-panel mosaic – a stunning journey through the depths of the night sky."

Equipment: ZWO ASI6200MM Pro camera, SharpStar 20032PNT reflector, Sky-Watcher EQ8 mount
Exposure: Ha 612x 300", OIII 900x 300", SII 900x 300", total 201h
Software: PixInsight, Astro Pixel Processor

ENTER YOUR IMAGE

Whether you're a seasoned astrophotographer or a beginner just starting out, we'd love to see your images. Send them to us at www.skyatnightmagazine.com/send-us-your-astrophotos

BBC wildlife

TRY 3 ISSUES FOR £6*

when you subscribe to *BBC Wildlife* magazine

BBC wildlife
OCTOBER 2024
A NEW HOPE
The sanctuary giving chimps a foothold in Sierra Leone
Plus
How cattle can help wildlife
Return of the mammoths
Essential guide to great white sharks
WILDLIFE PHOTOGRAPHER OF THE YEAR WINNERS
DECEMBER 2024
THE BEST NATURE BOOKS OF 2024
the epic new BBC series

- Try your first **3 issues for just £6***
- Continue to pay just **£22.99 every 6 issues - saving 30%** off the shop price
- **Free UK delivery** direct to your door in environmentally friendly wrapping
- **Never miss an issue** of the world's oldest and best-selling wildlife magazine!

Subscribe online or call us...

Visit **www.ourmediashop.com/WLHA25**

or call **03330 162 121**† QUOTE CODE **WLHA25**

*3 issues for £6 available to UK Direct Debit orders only. After your first 3 issues, your subscription will continue at just £22.99 every 6 issues, saving more than 30% on the shop price. If you cancel within two weeks of receiving your second issue, you will pay no more than £6. Your subscription with start with the next available issue. †UK calls will cost the same as other standard fixed line numbers (starting 01 or 02) and are included as part of any inclusive or free minutes allowances (if offered by your phone tariff). Outside of free call packages, call charges from mobile phones will cost between 3p and 55p per minute. Lines are open Mon to Fri 8am-6pm and Sat 9am-1pm. Offer ends 31st January 2026.

The best in equipment, accessories and books each month

REVIEWS

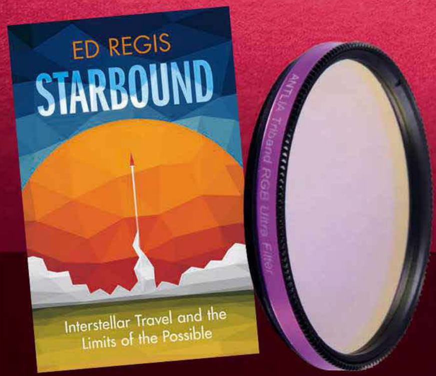
SUBSCRIBE
Discover the best new kit every month
SEE PAGE 26

Find out more about how we test equipment at
www.skyatnightmagazine.com/scoring-categories

86

Looking for a full-frame camera that excels at astrophotography? Find out how Canon's mirrorless R8 fared in our test

Canon
EOS
R8


ED REGIS
STARBOUND
Interstellar Travel and the Limits of the Possible

PLUS: new books on far-out plans to reach the stars, a planisphere for newbies and more, plus a roundup of cool astro gear

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★☆ Very good
★★★☆☆ Good ★★☆☆☆ Average ★☆☆☆☆ Poor/avoid

@THESHED/PHOTOSTUDIO

Canon EOS R8 mirrorless camera body

This mid-range full-frame camera handles deep-sky demands with aplomb

WORDS: PAUL MONEY

VITAL STATS

- **Price** £1,699.99 (body only)
- **Sensor** 35.9 x 23.9mm, 24.2MP full-frame CMOS
- **ISO range** 100–102,400 (expandable to 204,800)
- **Frame rate** 40fps burst
- **Resolution** 6,000 x 4,000
- **Body size** 132.5 x 86.1 x 70.0mm
- **Connectivity** Wi-Fi, Bluetooth, Canon Camera Connect app, RS-60E3, USB-C, audio/ headphones, HDMI
- **Weight** 461g (with battery and SD card)
- **Supplier** Canon UK
- **Tel** 020 7660 0186
- **www.**canon.co.uk

Cameras have come a long way and, until recently, DSLRs, which use a flip-up mirror to see through the lens, have dominated the market due to their mix of capability and accessible pricing. But the digital age is maturing and mirrorless cameras are now becoming much more affordable. Here we look at Canon's mid-range full-frame offering, the EOS R8, to see how it fares as an astrophotography camera.

The R8 is sturdily built yet incredibly lightweight at just over 450g, so won't strain the focuser on your telescope. For standard photography, it has a wide range of useful functions for the creative photographer. Canon has retained the button and dial layout you'll find on many others in its range, with only minor changes to the R8, such as a dedicated switch for still frames or video mode.

It has a smaller battery, which we found lasted for around 180 images, depending on the temperature. The three nights during the review period were quite cold, which can seriously affect battery capacity. After each session on one target, we needed to recharge, so we'd suggest either buying spare batteries or using an adaptor to power the camera from an external source.

The R8's touch-operated LCD screen can flip out and be tilted, which is very useful when mounted on a telescope, where the back of the camera is often at an awkward viewing angle. You can also view objects through the LCD viewfinder like on traditional cameras, but bear in mind that both options only work when the power is turned on.

Touchscreen control

The touchscreen is multifunctional. One essential feature is that the view can be magnified by 5x and 10x, allowing you to zoom in to manually focus on a star, which works brilliantly. The screen also provides direct access to the shooting mode, ISO and other capture functions useful to astrophotographers, so you can quickly change settings in the field without feeling for the physical buttons. ▶

Canon
EOS
R8
CANON LENS RF24-50mm F4.5-6.3 IS STM

LENS NOT INCLUDED

ALL PICTURES: @THESHED/PHOTOSTUDIO

SCALE

LENS NOT INCLUDED

Camera body

Lightweight and sturdy, the R8 has a range of button and dials for optimising its performance, depending on your astronomy target. Those familiar with Canon cameras will find most of the controls laid out as expected, with just a few minor changes.

M-Fn
OFF
LOCK
ON
MENU
INFO
Canon

Canon
EOS
R8

Tilting touchscreen

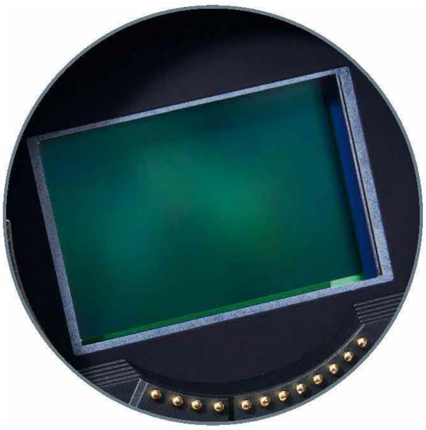
Tilting LCD screens have really helped astrophotographers, as often targets are high in the sky, putting the screen at an awkward position. The R8's tilting screen shows many of the currently set camera functions. You can also take an image by touching the screen.

P
[1668]64
02:00:00
MF
AWB
FULL
Exp.SIM
10000
MENU
AF ON
INFO
SET
CAUTION! SCREEN STORAGE COMPARTMENT MAY GET HOT. DO NOT TOUCH.

Sensor suited to night sky

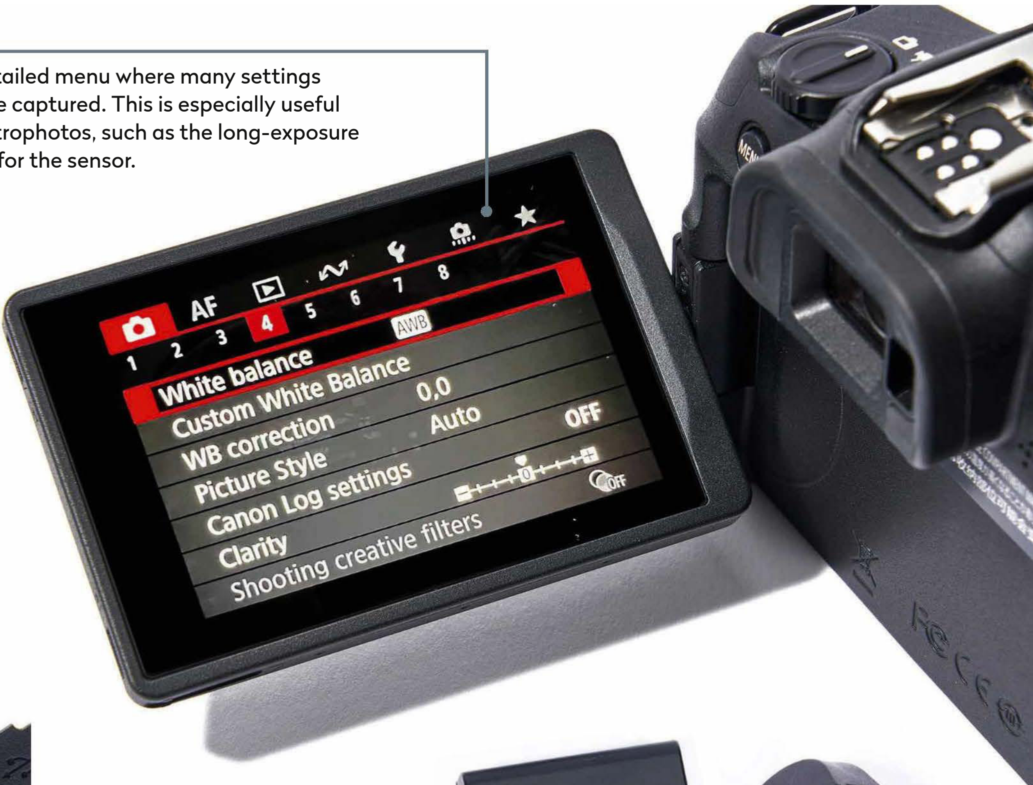
The R8 boasts a 24.2MP full-frame CMOS sensor. 'Full frame' means it is the equivalent of the original standard format for cameras, giving a 3:2 aspect ratio or, to put it another way, 36 x 24mm. This gives a CR3 raw image size of 6,000 x 4,000 pixels – so plenty of sensor to capture the night sky with.

The ISO range is considerable, going from 100 to 102,400, and is pushable up to 204,800. However, note that due to light pollution, most of our sky conditions render higher values useless. The good news is that if you use filters, such as tri- or quad-band filters, then although they do dim the image a little, the mid-range ISO values can help. Indeed, for all our images taken during the review period, we used an ISO of 10,000, with only slight noise apparent that was easily reduced in processing. If you're using a guiding setup, you can reduce the ISO to 6,400 or less to increase exposure times and get even better results.



Detailed menu

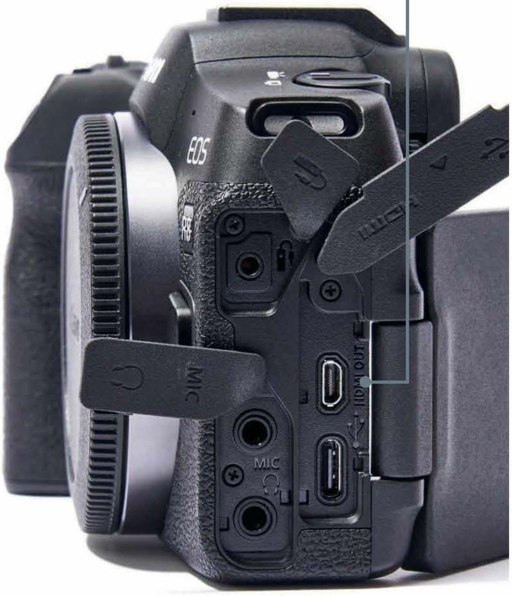
The LCD screen provides access to a very detailed menu where many settings can be changed to enable the best data to be captured. This is especially useful for turning off features that may degrade astrophotos, such as the long-exposure noise reduction, or for altering the crop ratio for the sensor.



White balance AWB
Custom White Balance
WB correction 0,0
Picture Style Auto
Canon Log settings OFF
Clarity
Shooting creative filters OFF

Connectivity

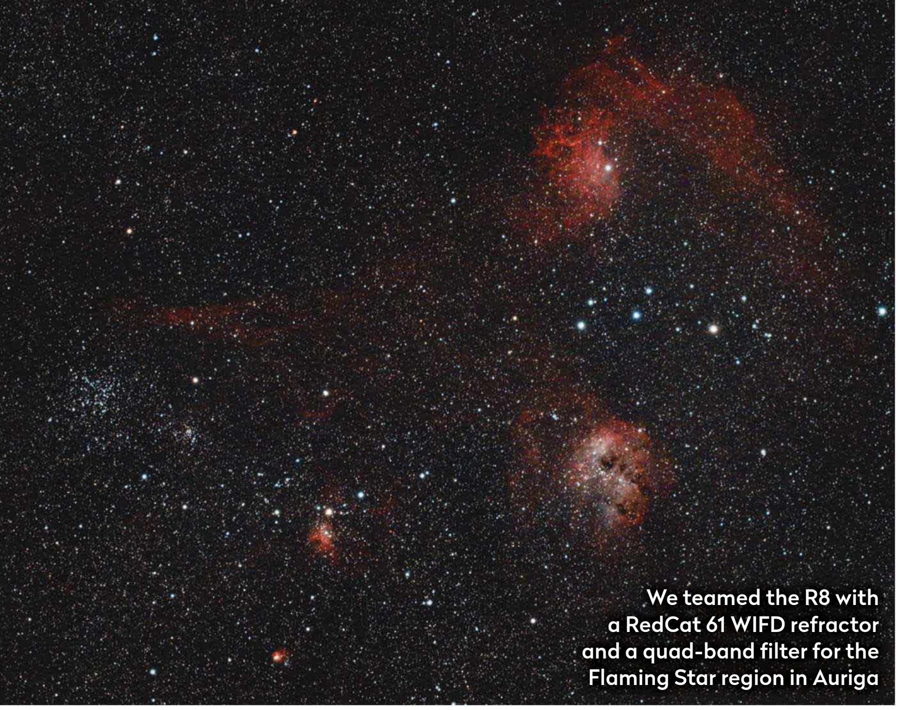
A wide variety of options can be found on the side of the camera for attaching accessories such as an intervalometer, microphone and headphones, HDMI output and USB-C connector. The R8 also boasts Wi-Fi and Bluetooth connectivity to control the camera or download images to a smart device.



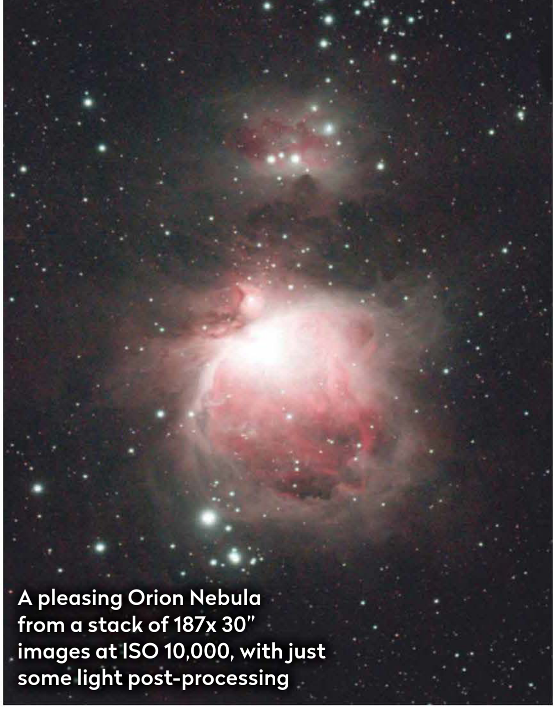
Battery and charger

Canon provides a camera strap, a charger with a UK-style cable/plug and a single rechargeable Li-ion LP-E17 battery. Under normal daytime use, the battery can last for 370 shots; for astrophotography, we achieved 180–200 shots before it needed recharging. The charger displays an orange light when charging and green when charged.

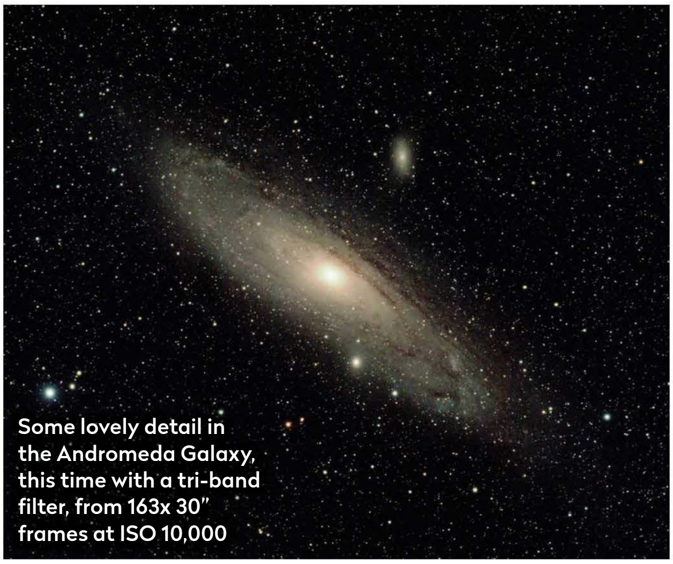
Canon
CHARGE
FULL
FUSED
Canon



We teamed the R8 with a RedCat 61 WIFD refractor and a quad-band filter for the Flaming Star region in Auriga



A pleasing Orion Nebula from a stack of 187x 30" images at ISO 10,000, with just some light post-processing



Some lovely detail in the Andromeda Galaxy, this time with a tri-band filter, from 163x 30" frames at ISO 10,000

▲ We switched the R8 to an Equinox 80ED refractor for the Pleiades. This is a stack of 439x 10" exposures

▶ We would highly recommend turning off the noise-reduction setting for long exposures in the menu or you may find that you lose the fainter stars in your images. There are so many useful settings, it really is worthwhile studying the manual in detail to get the best out of the camera.

One of the differences between the R8 and its mid-range sibling the Canon Mk I R6 is that the R8 has only one SD card slot (for a UHS-II SD card, not provided), located in the battery compartment. Another is that Canon has opted to use a 24MP sensor for the R8, compared with the Mk I R6's 20MP sensor. It's worth noting that the 24MP sensor is used in the latest R6 model, the Mk II. The difference in image size isn't that obvious at a quick glance, but in raw image mode using Canon's CR3 file format, the image dimensions are 6,000 x 4,000 pixels compared with the original R6 Mk I at 5,472 x 3,648 pixels.

Time for a deep-sky workout

We attached the R8 to our RedCat 61 apo refractor and were able to image the Flaming Star region in Auriga, the Orion Nebula up to the Flame Nebula region, and the Rosette Nebula, all captured with a quad-band filter to compensate for light pollution. Even with the Flaming Star image consisting of only 113 images at ISO 10,000 and 30-second exposures, we were impressed with our results after some processing with Astro Pixel Processor and PaintShop Pro. Turning to the Andromeda Galaxy, M31, we swapped to using our tri-band filter with the RedCat and again were pleased with the stacked and processed image. We did find that being a full-frame sensor, the R8 produced distorted stars when combined with our Equinox 80ED refractor and field flattener, which were evident in our image of the Pleiades star cluster, but this was as expected.

Overall, we thoroughly enjoyed using the Canon EOS R8 mirrorless camera, with its lightweight body, easy-to-use interface and impressive performance as an astrophotography device. We would highly recommend it.

VERDICT

Build & design	★★★★☆
Connectivity	★★★★★
Ease of use	★★★★☆
Features	★★★★☆
Imaging quality	★★★★☆
OVERALL	★★★★☆

KIT TO ADD

1. Canon RF 24–50mm f/4.5–6.3 IS STM zoom lens

2. T-ring telescope adaptor for Canon R cameras

3. Intervalometer

©THESHED/PHOTOSTUDIO X 4, PAUL MONEY X 4

Our experts review the latest kit

FIRST LIGHT

Ikarus Technologies
StellarMate Pro 128GB

A powerful command centre for all your gear… once you've got the hang of it

WORDS: CHARLOTTE DANIELS

VITAL STATS

- **Price** £599
- **Size** 165mm x 125mm x 35mm
- **Weight** 600g
- **Connectivity** HDMI, Wi-Fi, ethernet
- **Ports** 4x USB 3.0, 2x USB 2.0, 1x USB-C, 4x 12V power, 2x dew heater, 2x auxiliary
- **Protocol** INDI
- **Extras** StellarMate app, 2x power cables, power adaptor
- **Supplier** First Light Optics
- **Email** questions@firstlightoptics.com

Astrophotography controllers have become increasingly popular, providing a single platform that acts as a command centre for running your imaging setup. Depending on your equipment, they can automate imaging processes and perform wider functions, including polar alignment, remote access and guiding.

Some controllers on the market are 'locked' to individual manufacturers, only working with specific brands. Step in Ikarus Technologies' StellarMate Pro, which not only claims to perform the above functions but also to connect with a wide selection of INDI-compatible equipment. We put this to the test with our setup, comprising a Sky-Watcher mount, Starlight Xpress CCD, guide camera and filter wheel, and Pegasus auto focuser.

While the StellarMate Pro doesn't come with a power supply as standard, an XT-60 power adaptor is provided, meaning it can connect to any aftermarket 12V/10A DC option. After downloading the StellarMate application and creating an account, we were ready to connect our equipment.

Once we'd screwed on the GPS and Wi-Fi antennas, the handy Quick Start guide helped us to complete the initial setup. First connecting our equipment to the USB and power ports, we then plugged the StellarMate Pro in and waited for a beep to signify that its Wi-Fi hotspot was ready. We easily found the network on our smartphone and used the default passcode (found in the online manual) before connecting to the unit via the app without issue.

No driver issues

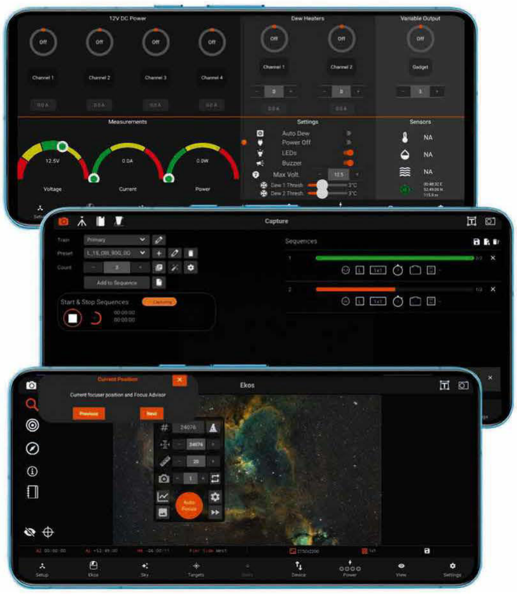
The next stage we were sceptical about. We hadn't downloaded any drivers for our equipment, so would the app connect to them? Heading to the setup module of the app, we set about creating equipment profiles for each item. We were pleased to see that there were driver options for every item in our kit and so within 10 minutes these were set within our 'optical train' profile. ▶

Easy-to-use app

Ikarus Technologies provides a highly functional app to control the StellarMate Pro. Available for both Android and iOS devices, we used it to set up, plan and run our entire workflow, from creating our equipment profiles to scheduling imaging sequences, taking calibration images and even performing polar alignment and guiding routines.

We particularly loved the fact that the INDI drivers for all our devices were already available in the Setup menu, meaning that connecting our equipment was a breeze. The Ekos module – where we set our imaging runs – was easy to use and allowed us to plan routines based on when targets would be visible from our location.

Meanwhile, the Sky feature is a brilliantly convenient planetarium that shows how targets will appear for the field of view of your particular camera(s), without you having to consult another app or website. While some features feel clunky – the app is fixed in a landscape position, for example, and won't rotate or resize – the scope of what it can achieve is impressive.

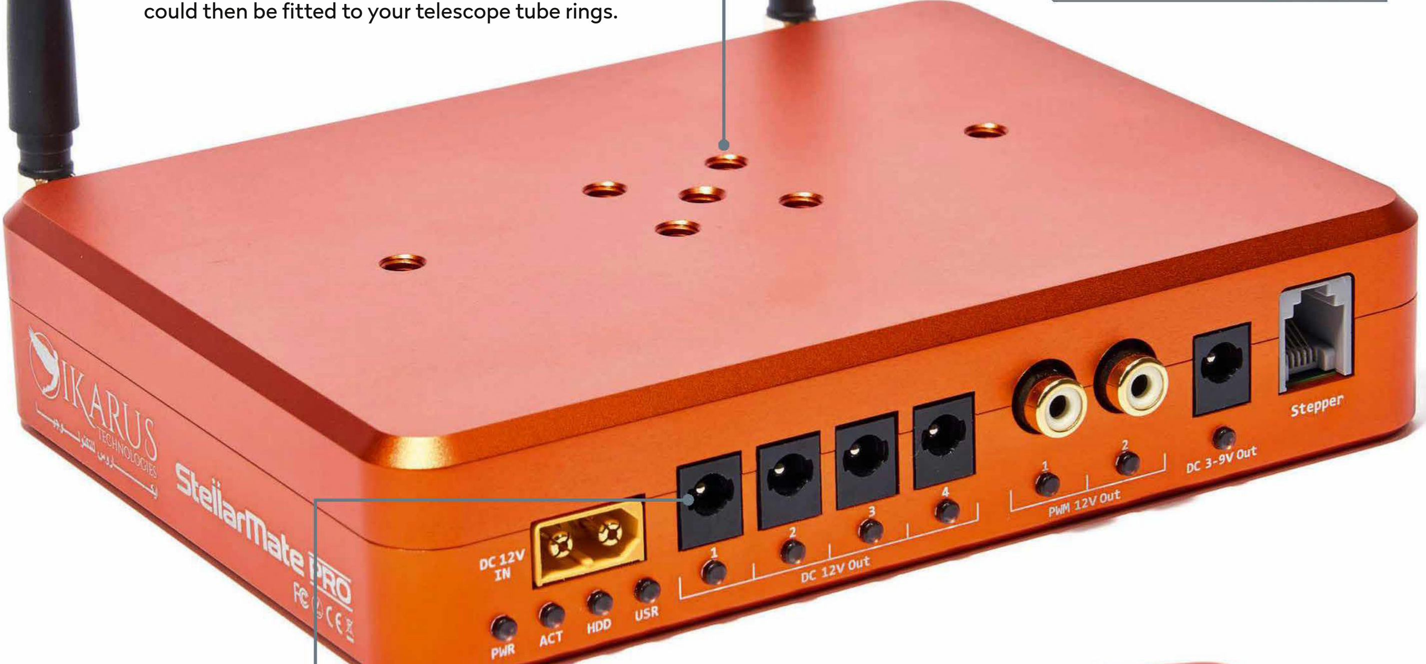


@THESHED/PHOTOSTUDIO X 3, SCREENSHOTS: CHARLOTTE DANIELS X 3

Built-in mounting threads

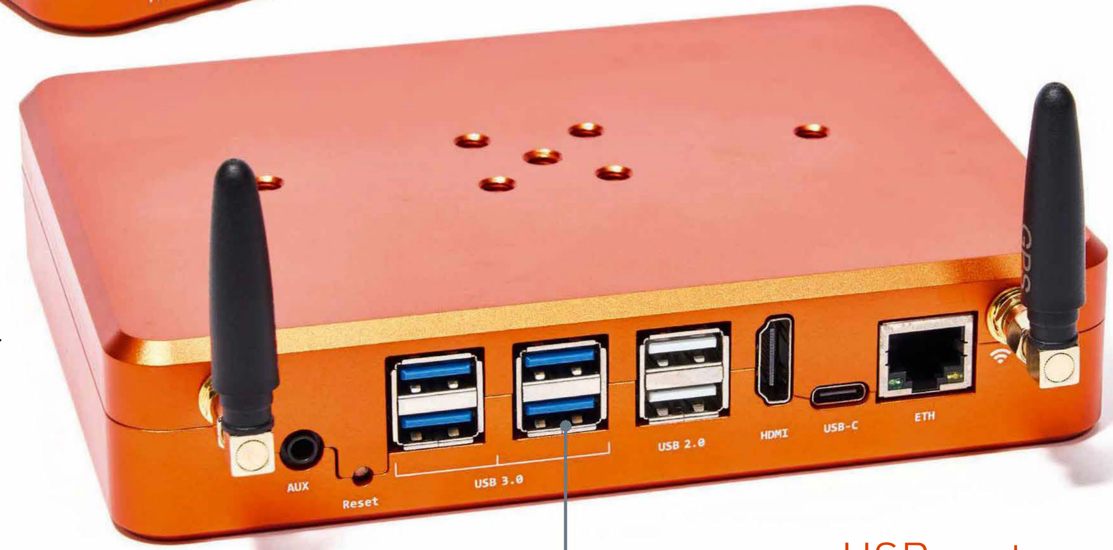
The StellarMate Pro's CNC aluminium case is equipped with 0.25-inch/M6 threads, allowing you to clamp the unit to your setup. Ikarus Technologies sells a dovetail clamp to attach the controller to a dovetail bar which could then be fitted to your telescope tube rings.

SCALE


IKARUS TECHNOLOGIES
StellarMate PRO
DC 12V IN
PWR
ACT
HDD
USR
1
2
3
4
DC 12V Out
1
2
PWM 12V Out
DC 3-9V Out
Stepper

Power ports

The unit can power up to four 12V DC astronomy accessories. We particularly liked the additional two ports for dew heaters which meant that our entire suite of equipment could effectively be powered through the unit, tidying up our cable runs. There's also a handy power health module in the StellarMate app.

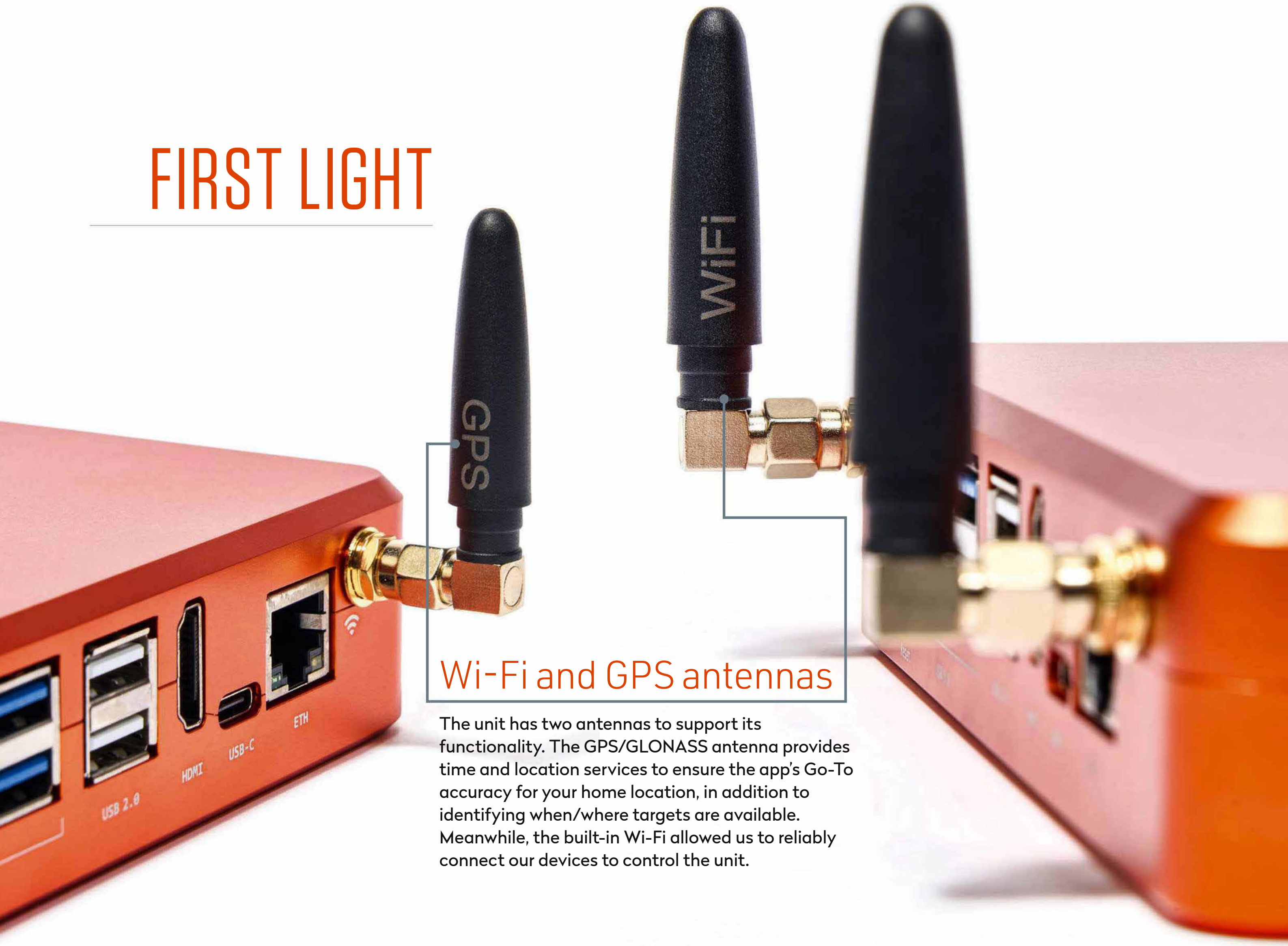

AUX
Reset
USB 3.0
USB 2.0
HDMI
USB-C
ETH
GPS

USB ports

An impressive six USB ports are available, providing ample connection options for an array of astrophotography equipment including mount, camera, filter wheel and auto focuser. With an HDMI cable (not included), you can also connect it to a monitor, while the USB-C port can be used for downloading data to a desktop or laptop if required.

Power cables

The StellarMate Pro doesn't come with a power supply, but an XT-60 to DC female power adaptor is included for easy connection to a 12V/10A DC supply. It also comes with two 5.5 x 2.1mm DC male-to-male cables, one 100cm and one 50cm long, to connect and power your equipment.



Wi-Fi and GPS antennas

The unit has two antennas to support its functionality. The GPS/GLONASS antenna provides time and location services to ensure the app's Go-To accuracy for your home location, in addition to identifying when/where targets are available. Meanwhile, the built-in Wi-Fi allowed us to reliably connect our devices to control the unit.

▶ The StellarMate Pro isn't quite a plug-and-play unit, however. While setting it up largely lived up to expectations, it wasn't completely straightforward. For example, the app was clunky. The font doesn't resize depending on your device screen and so larger tablet screens are better suited. The online manual is essential reading simply to get to know everything this unit can do and while it's comprehensive, it is rather huge.

Nevertheless, the process to connect equipment was smooth and we were soon using the Sky module to slew to objects. It was time to set our imaging sequences in the Ekos module, building our 'preset' jobs to define exposure times, gain and the number of frames before adding them to our sequence in the Capture screen.

Worth the learning curve

After a couple of attempts, we were capturing dark frames before slewing over to the Heart Nebula, our filter wheel whirring into life as scheduled. The main snag we hit was setting up our auto focuser, which at first wouldn't start, despite successful connection. It turned out that we'd missed a screen that allowed us to define the focuser settings; after this, it auto focused without issue.

We'd advise against setting up and capturing an image on your first night; set aside a couple of days simply to create your equipment profiles, plan imaging sequences and connect equipment. Once you get to know the flow of the StellarMate app, everything starts to make sense, although even as experienced imagers we found ourselves repeatedly consulting the manual.

Another drawback is that most of the app is unavailable once the StellarMate is disconnected; the unit needed to be on and connected to set equipment profiles and image sequences.

Nevertheless, there's so much to love about the StellarMate Pro. We see it as an excellent all-in-one controller for experienced astrophotographers who love to tinker, adapt and customise their workflows. From polar alignment to planning and capture, the unit does it all. The sheer functionality offered by this compact accessory is market-leading, but it does require time. As our review period ended and we handed the StellarMate Pro back, we knew we were going to miss it.

VERDICT

Build & design	★★★★★
Connectivity	★★★★★
Ease of use	★★★☆☆
Features	★★★★☆
Guiding accuracy	★★★★☆
OVERALL	★★★★☆

KIT TO ADD

1. Ikarus Technologies temperature sensor
2. StellarMate 12V/10A DC power supply
3. StellarMate dovetail clamp

ALL PICTURES: @THESHED/PHOTOSTUDIO

CRUISE COLLECTIVE

Set sail for adventure with Cruise Collective

Explore stunning destinations and unforgettable experiences. Whether you seek relaxation or adventure, Cruise Collective has your perfect escape

Join Cruise Collective for free today

cruise-collective.com

ENJOY YOURSELF

THE BEST VALUE AT SEA

We offer an authentic, no-fly cruise experience with the warmest welcome at sea. Plus, with our onboard currency in GBP£, avoid exchange rates and enjoy quality sailing at an affordable price.

AMBASSADOR
CRUISE LINE
AMBIENCE

AMBASSADOR™
CRUISE LINE

Discover our flagship, Ambience

WINNER
BRITISH TRAVEL AWARDS 2024
BEST CRUISE LINE FOR NO-FLY CRUISE HOLIDAYS

feefo ★★★★★ 4.7/5
Service Rating 1,846 Reviews

THE WARMEST WELCOME AT SEA

BOOK YOUR SAILING TODAY
ambassadorcruiseline.com
Call 0808 258 0853

EDITORS' PICKS cruisecritic ★★★★★ 2023
Best Value for Money (Ocean)

CRUISERS' CHOICE cruisecritic ★★★★★ 2023
Best UK Mid-Size Cruises Overall

ABTA
ABTA No. Y6765

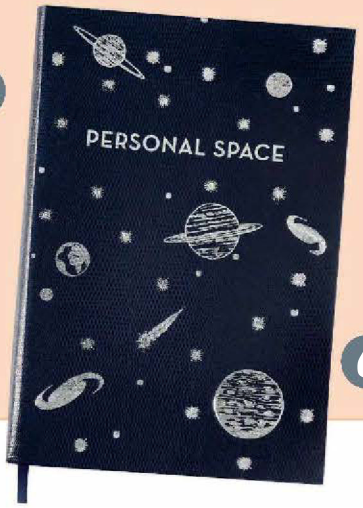
SILVER TRAVEL AWARDS 2024
WINNER

Cruise holidays booked with Ambassador Cruise Holidays Limited, trading as Ambassador Cruise Line, are financially protected in accordance with the Package Travel and Linked Arrangements Regulations 2018. Copyright 2024. Ambassador Cruise Holidays Limited is a company registered in England and Wales. Registered number: 13299365.

Charlotte Daniels rounds up the latest astronomical accessories

GEAR

ANTLIA Triband RGB Ultra Filter
2



1 Oklop padded bag for small telescopes

Price £58 • **Supplier** Rother Valley Optics
www.rothervalleyoptics.co.uk

A well-fitting, padded bag can be an excellent and safe method for transporting your equipment to dark locations. Oklop's version for small telescopes can fit refractors up to 90mm or Newtonian reflectors up to 130mm aperture and 900mm focal length.

2 Antlia 2-inch tri-band RGB ultra filter

Price £188 • **Supplier** 365 Astronomy
www.365astronomy.com

ADVANCED This tri-band filter allows H-alpha, OIII and SII wavelengths to reach colour camera sensors while supressing the effects of light pollution. It can also be used as a luminance filter for mono cameras with RGB filters to boost contrasts.

3 Lego Apollo lunar roving vehicle

Price £189.99 • **Supplier** LEGO
www.lego.com

Comprising over 1,900 pieces, this stunning Lego Technic model of the Apollo 17 lunar rover module, complete with three equipment sets, is a perfect tribute to NASA's historic programme. Suitable for the space-loving young at heart, ages 18 and over.

4 NASA Blast Off! cushion

Price £19.99 • **Supplier** IWOOT
www.iwantoneofthose.com

This striking 30cm x 50cm rectangular cushion will add a retro nod to space exploration to any room. Featuring a double-sided design, plump cushion insert and hidden zipper, the soft-touch fabric makes for a cosy and nostalgic addition to your sofa or bed.

5 iOptron mini pier extension

Price £118 • **Supplier** Altair Astro
www.altairastro.com

If you've recently bought or made a pier for your mount, the chances are that a pier extension is on your wish list. iOptron's miniature pier has a 150mm top plate and provides 8 inches of additional height for a wide range of iOptron Go-To mounts.

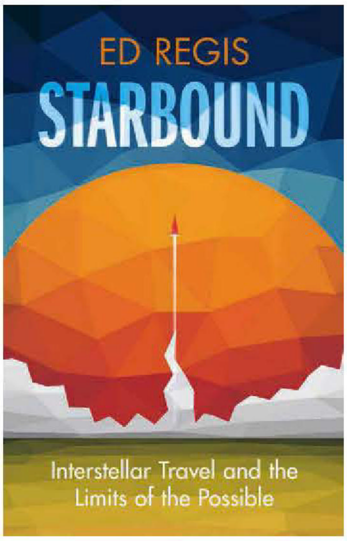
6 Cosmic notebook

Price from £49 • **Supplier** Sloane Stationery
www.sloanestationery.com

This hardcover A5-sized notebook is beautifully embossed with astronomy images, from planets and galaxies to shooting stars. Handmade in England, it's a perfect home for recording your cosmic adventures. Also available in A4 size for £59.

New astronomy and space titles reviewed

BOOKS

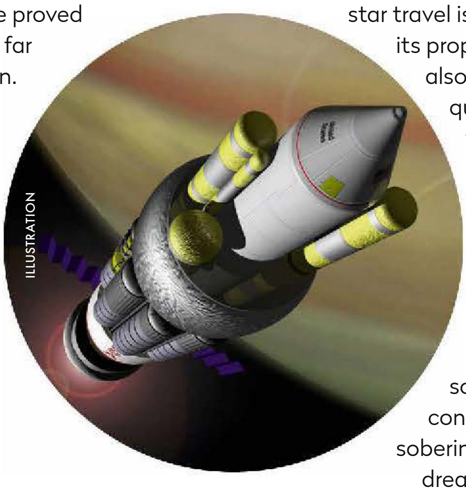


Starbound

Ed Regis
Cambridge University Press
£25 ● HB

Whenever the subject of interstellar travel is discussed, Arthur C Clarke's first law – stating that when a distinguished scientist claims something is 'impossible', they will very likely be proved wrong – will rarely be far from the conversation. The dream of journeying to the stars has been with us for centuries and is such a staple of popular imagination that we can all too readily assume it represents an inevitable future.

In *Starbound*, Ed Regis provides an enlightening corrective to the assumption that reaching the stars is merely a matter of time, effort and inexorable technological progress. Throughout its information-packed, engagingly written pages, he applies a rigorous eye to both the broad-brush concepts of human interstellar travel and the fine detail of countless specific proposals. Warp drives, nuclear power, antimatter and other speculative forms of propulsion are all shown to founder on closer examination. Multi-generational 'world-ships' (and that sci-fi favourite, suspended animation), meanwhile, raise a host of questions about practicality, human biology and behaviour, and even morality. It's Regis's engagement with potential failures that really brings the point home, however. When the tiniest technical problem could doom an interstellar mission, who would sanely commit the vast resources required with such a minuscule chance of success?



Mission impossible: bomb-driven Project Orion, one of several doomed star-voyager schemes

NASA

Although the analysis is serious, the tone is leavened with anecdotes and occasional incredulity at some proposed schemes. Project Orion, for example, a 1950s proposal for a spacecraft propelled by the ejection and detonation of countless small nuclear bombs, sounds like one of Wile E Coyote's more foolhardy inventions, yet it was funded and developed for almost a decade.

If his overwhelming message is that star travel is a lot harder than its proponents argue, Regis also raises important questions about why we should even attempt it. His penultimate chapter reviews all the common arguments for voyaging to other stars and finds them sorely wanting. His conclusions may be sobering for interstellar dreamers, but this revelatory book carries lessons about our broader susceptibility to scientific and technological boosterism that we might all do well to digest.

★★★★★

***Giles Sparrow** is a science author, editor and consultant*

Interview with the author

Ed Regis

Is interstellar travel possible?

As a theoretical possibility? Yes. As a workable technology that's within our reach, within our current engineering capability and our willingness to finance such a gigantic, complex and technically challenging project? No. Even the nearest stars are incredibly far away. And the only propulsion systems currently available are chemical systems, which are not nearly powerful enough to propel us across such vast distances.

If humanity could leave today, where should we go?

A 'mirror Earth'. It must be a rocky planet with liquid water, a breathable atmosphere, gravity that's neither too strong nor too weak, orbiting a star bright enough to permit human vision. The Habitable Worlds Catalog lists 70 potentially habitable worlds ranked on an 'Earth Similarity Index'. All top 10 candidates orbit red dwarf stars which emit mostly in the infrared, not visible light – meaning that currently we have nowhere to go.

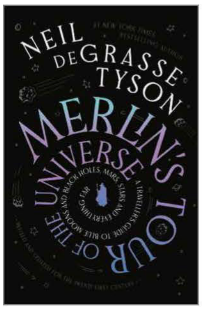
Is interstellar travel a necessity for our species?

Certainly not. We already have the whole Solar System available for colonisation – planets and satellites, plus locations in free space for O'Neill-type space colonies. Getting a founding human population to any of those would be a wildly expensive and technically challenging undertaking. The difficulties only multiply exponentially when the destination is another Solar System lightyears away. Interstellar travel is therefore unnecessary and, given its risks and costs, not worth it.

***Ed Regis** is a philosopher, educator and science author*

Merlin's Tour of the Universe

Neil deGrasse Tyson
Black & White Publishing
£16.99 ● HB



Meet Merlin, a resident of the planet Omniscia in the Andromeda Galaxy, who has observed all of the major scientific breakthroughs and events throughout human history. Armed with his wit and knowledge, in *Merlin's Tour of the Universe* he answers over a hundred questions that the public have posed to him about... well, anything!

Neil deGrasse Tyson originally created Merlin as a vehicle to write a question-and-answer column for an astronomy magazine and this is where most of the content of this book first appeared. It has now been fully updated and revised for this latest edition. Around half of the book answers questions related to our Solar System, including the Moon, our planets, the Sun, asteroids, comets and what it means to be a stargazer. The second half of the book's questions delve into a variety of topics, including gravity, galaxies, telescopes and black holes. The Q&A format makes this book a quick and easy read. The sections are also delightfully short. Admittedly, in places this is a disadvantage where more explanation is needed. However, this is purposely not an astronomy tutorial.

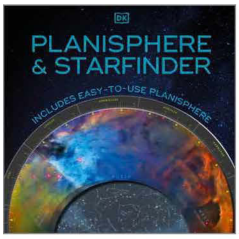
Yet it's difficult to say who the audience for the book really is. The questions are randomly placed and on a variety of different topics, so the reader may not get an answer to their own particular question. But *Merlin's Tour of the Universe* is easy to understand, enjoyable and written with Tyson's usual flare. So, if you think you'll enjoy short, witty answers to popular astronomy questions, some of which are served up with cute illustrations, then look no further. ★★★★☆

***Laura Nuttall** is professor of gravitational wave astronomy at the University of Portsmouth*

Planisphere & Starfinder

BEGINNER FRIENDLY

Various
DK
£16.99 ● HB



Planisphere & Starfinder was first published in 2007 and has since undergone various revisions to bring the book up to date for this latest edition. In this era of smartphones and apps, it's lovely to see a book published with a planisphere that can be removed from the inside cover and used from northern latitudes to stargaze throughout the year. No batteries required!

A practical hardback guide for complete beginners, the book spans 128 pages which are divided over four sections, each covering a brilliant range of topics to keep keen newbies captivated. The fundamentals of looking up to the sky are explained, before wide-eyed beginners are taken on a journey through the Solar System, each planet and object succinctly explained.

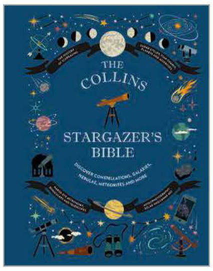
The bulk of the book is dedicated to the 88 constellations, descriptions of which are brief, but each is presented clearly and simply using locater charts, pictures painting a thousand words. Every constellation includes a list of stars and other features that can be found within its borders and these are handily labelled with symbols to identify whether they can be viewed with the naked eye or require optical aids.

The monthly guide to the night sky in the final section is a real highlight, particularly the special events that span well into the future. Colourful, informative, well thought out and richly illustrated with glossy photographs and diagrams, this guide, together with the planisphere, will be a faithful companion to anyone starting out in practical astronomy. ★★★★★

***Katrin Raynor** is an astronomy writer and communicator*

The Collins Stargazer's Bible

Ian Ridpath, Mary McIntyre, Rachel Federman
William Collins
£30 ● HB



This comprehensive introduction to the night sky is certainly biblical in length, with four lengthy chapters covering different aspects of astronomy: the practical aspects of choosing and using a telescope, detailed star charts, a history of astronomy and advice on how to capture aesthetically pleasing astronomy images.

Important astronomical discoveries from Ptolemy onwards are clearly explained and there is a greater emphasis on the history of mapping the heavens and the evolution of the constellations than you'll find in shorter introductions. Biographical sketches of astronomers also provide historical interest.

The science behind the observations is not neglected, however, with a nice discussion of stellar evolution and the Hertzsprung–Russell diagram, as well as some aspects of objects ranging from our Solar System planets to galaxies (although hardly anything about cosmology is included). Each constellation has its own chart, but some are difficult to use because the typeface is so small. And the included instructions for the star charts are brief, so they may need to be augmented by consulting other guides.

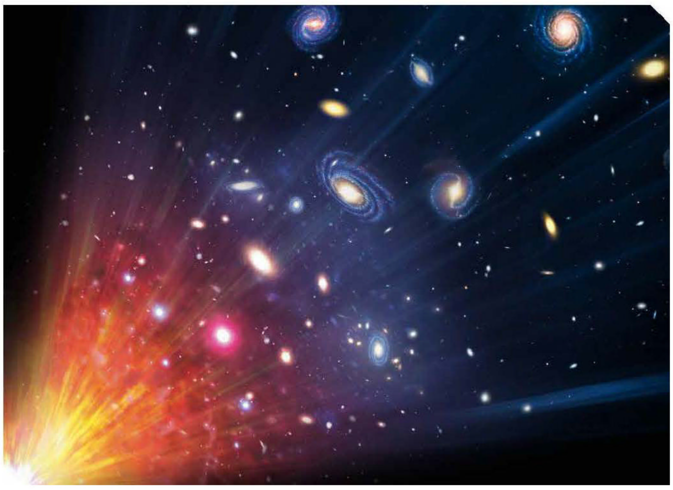
The final chapter discusses 'the art of the sky' and includes beautiful depictions, from prehistoric times and the Nebra sky disc up to more modern art such as Vincent van Gogh's 1889 painting *The Starry Night*, with its swirling galaxies. The book concludes with guidance for artistic projects including timelapse videos, sunspot images and creating astronomical art with pastels. This unusual mix of science and art makes the book a handy introduction to astronomy's technical aspects that also highlights its central importance to human culture. ★★★★☆

***Pippa Goldschmidt** is an astronomy writer*

Anita Chandran talks to Professor David Wiltshire

Q&A WITH A DARK ENERGY SCEPTIC

Dark energy is key to cosmologists' theories of what shapes the Universe, but could a new idea known as Timescape soon overthrow it?



▲ **Instead of using dark energy to explain the expansion of the Universe, Timescape says denser regions of space make time behave differently**

What is dark energy?
Dark energy is an unknown quantity, introduced to explain how observed astronomical data aligns with our understanding of the standard model of cosmology. In the 1990s, scientists observed supernovae – exploding stars – and found from their observations that the Universe is expanding at an accelerated rate. You need something to explain that apparent acceleration. Dark energy is a mysterious substance which exists everywhere and has a repulsive quality or 'negative pressure'. In other words, it's pushing outwards everywhere. It can be added to the equations to make them consistent but otherwise it's a mystery, which is unsatisfying to many scientists.

What's wrong with our theory of dark energy?
A huge question is the Hubble tension. The rate of the Universe's expansion appears to vary depending on how you measure it – that's a major problem for standard cosmology. Anomalies in the cosmic microwave background radiation – left over from the Big Bang which pervades the entire Universe – are also not explained. Other similar anomalies exist, for example in the distribution of far-away quasars and radio galaxies, or the abundance of lithium measured in the oldest stars. With better observations, like those from JWST, we're seeing more of these cracks in the theory of dark energy.

How is the Timescape model different?
Timescape is an alternative model for the Universe's expansion history using Einstein's general theory of relativity while revisiting its fundamental principles. Our current model of the Universe is called Lambda cold dark matter or 'Lambda CDM' (ΛCDM). It assumes the Universe is a perfectly homogeneous soup of particles. In this model, dark energy propels the Universe's accelerating expansion.

Timescape instead proposes that the complex cosmic web of structures that we actually observe – galaxy clusters in sheets and filaments that surround and thread vast empty voids – impacts its expansion. Instead of being homogeneous, the Universe is clustered into patches which each evolve differently. And clocks run slower where matter is concentrated. In Timescape, time and space behave differently in voids compared to areas of high matter density. For example, if you looked at the same clock inside a void and on Earth, you would see that the clock in the void would run faster. In this model, what we interpret as an accelerating expansion is instead an expansion which is decelerating everywhere, but decelerating far less in voids where there's significantly less matter. When voids grow to dominate the volume of the Universe it just appears to us that expansion is accelerating when that's not the case.

MARK GARLICK/SCIENCE PHOTO LIBRARY/GETTY

David Wiltshire is a theoretical physicist at the University of Canterbury, New Zealand. His research focuses on general relativity, cosmology and quantum gravity.

How did you check the accuracy of Timescape?
We analysed data from the Pantheon+ supernova catalogue and used it to statistically compare the ΛCDM and Timescape models. From our analysis, we are over 99 per cent confident that the Timescape model fits the supernova data better than ΛCDM.

What does it mean for our understanding of the evolution of the Universe if Timescape is correct?
In standard cosmology, the Universe will expand forever at an increasing rate (leading to a boring situation for astronomers: everything else will recede too far away for us to observe). In Timescape cosmology, we predict that the Universe is decelerating, just by different amounts in different places, so the sky will remain studded by galaxies.

Are there cases where ΛCDM has proven more likely than Timescape?
While with supernova data Timescape is preferred to ΛCDM, when a phenomenon known as baryon acoustic oscillations (BAOs) is included, then ΛCDM wins out. BAOs trace an excess of galaxies separated by a distance caused by sound waves in the early Universe. We actually find this discrepancy encouraging, since the BAO scale in the Timescape model hasn't yet been fully calibrated. To do that, we need to know how much dark matter is in a Timescape Universe, which is what we're currently researching.

Telescope House
Telescope Specialists Since 1785

HOSTED BY
BRESSER® UK

Load capacity: 15 kg in EQ mode & 20 kg in AZ mode

BRESSER®

NEW - Bresser Nebula 5 & 6 Dual EQ and Alt Az Mounts

These European-made mounts come complete with a built-in Raspberry Pi-based control system, allowing for easy Plate Solving and GoTo control and also management of a wide range of cameras, autoguiders, focusers, filter wheels, and more - all without locking you into a specific manufacturer's product line. This puts the Nebula mount at the heart of your astrophotography rig - easily enabling sequencing of all aspects of your imaging.

Available in two sizes: the ultraportable Nebula 5 and the more capacious Nebula 6 - these mounts are now available to order.

Please see our website for more details.

Load capacity: 18 kg in EQ mode & 25 kg in AZ mode

BRESSER®

NEW - Bresser Wifi Eyepiece camera. Stream and capture from your telescope

NEW - PushTo Beginner's Telescopes

PushTo AR-80/400 Smart Telescope with tripod

LUNT solar systems

We are proud to stock **LUNT MT** modular dual purpose Hydrogen Alpha AND conventional ED Refractors. Enjoy the convenience of two scopes in one, without sacrificing optical quality.

ED 60mm, ED 80mm, ED 100mm and **ED Triplet 130** versions all available

Vixen®

Introducing the new Vixen VSD90ss Astrograph

This extremely high quality 5 element f/5.5 astrograph builds on the foundations of the earlier VSD100 to bring astrophotograhers a new lighter weight system with improved optics, leading to higher Strehl ratios and incredibly flat fields - even at full frame format.

LUNT LS40 DOUBLESTACK
Now available!

Check out the **LUNT LS40** starter Hydrogen Alpha Solarscope

Website: https://www.bresseruk.com/Astronomy/
Email: sales@bresseruk.com | For sales and advice call: 01342 837098
All prices correct at time of press. Subject to change. Errors and omissions excepted.

Sky-Watcher®
Be amazed.

SYNSCAN™ PRO-SERIES GO-TO EQUATORIAL MOUNTINGS

SYNSCAN™ GO-TO

For astronomers seeking superior equatorial control for imaging or visual applications, Sky-Watcher's family of Synscan™ Pro-Series High Precision Computerised Mountings provide the solution. All models are premium grade observing platforms which have been thoughtfully designed for ease of operation. All models feature quiet operation and are equipped with an ST4 Auto-Guider interface for Astro-Imaging. The user-friendly Synscan™ hand control, with its extensive database of over 42,900 night sky objects, allows you to point the telescope at a specific object or even tour the night sky at the touch of a button. Even an inexperienced user can master its variety of features in a few observing sessions.

EQ3 PRO

Max Payload: 6.5kg
45mm Saddle
Product Code: 20230

SRP £599

EQM-35 PRO

Max Payload: 10kg
45mm Saddle
Product Code: 20980

Sky at Night MAGAZINE ★★★★★ REVIEWED IN Issue 160 September 2018

SRP £789

EQ5 PRO

Max Payload: 9kg
45mm Saddle
Product Code: 20981

SRP £829

AZ-EQ5GT PRO

Max Payload: 15kg
45mm Saddle
Product Code: 20302

Sky at Night MAGAZINE ★★★★★ REVIEWED IN Issue 121 June 2015

FREEDOM FIND™

SRP £1449

HEQ5 PRO

Max Payload: 18kg
45mm Saddle
Product Code: 20886

Sky at Night MAGAZINE GROUP TEST WINNER 92%

SRP £1169

EQ6 PRO

Max Payload: 25kg
Dual 45mm/75mm
Saddle
Product Code: 20854

SALE PRICE! SRP WAS £1489

Astronomy HOT Product

SRP £1199

EQ6-R PRO

Max Payload: 20kg (imaging)
Dual 45mm/75mm
Saddle
Product Code: 20855

Sky at Night MAGAZINE ★★★★★ REVIEWED IN Issue 145 June 2017

SRP £1679

AZ-EQ6GT PRO

Max Payload: 25kg Dual
45mm/75mm Saddle
Product Code: 20291

Sky at Night MAGAZINE ★★★★★ REVIEWED IN Issue 100 September 2013

SRP £1999

FREEDOM FIND™

CQ350 PRO

Max Payload: 35kg
45mm/75mm Saddle

CQ350 MOUNT HEAD
Code 20309
SRP £2599

CQ350 PRO WITH TRIPOD
Code 20309/20939
SRP £3198

STAR ADVENTURER MOUNTS

SRP £399

WI-FI

STAR ADVENTURER GTI MOUNT HEAD

SYNSCAN GO-TO

Version with tripod also available
Product Code: 20326

STAR ADVENTURER 2i PRO PACK

DSLR not included
Product Code: 50212

WI-FI

SRP £515

STAR ADVENTURER MINI PRO PACK

Product Code: 50210

WI-FI

BBC Sky at Night MAGAZINE ★★★★★ REVIEWED IN Issue 143 April 2017

SRP £269

EQ8-R & EQ8-Rh PRO

Max Payload: 50kg. 75mm Saddle. Hi-Res R.A. Renishaw Encoder on EQ8-Rh model

EQ8-R MOUNT HEAD
Code 20323 SRP £3799

EQ8-Rh MOUNT HEAD
Code 203234 SRP £6549

EQ8-R PRO WITH PIER TRIPOD
Code 20323/20923 SRP £4798

EQ8-Rh PRO WITH PIER TRIPOD
Code 20324/20923 SRP £7548

OVL

Available from dealers throughout the UK
OPTICAL VISION LIMITED

Full product details at:
www.opticalvision.co.uk
info@opticalvision.co.uk

THE SOUTHERN HEMISPHERE

With Glenn Dawes

With countless beautiful regions on show, autumn is a great time for our magnificent southern skies

When to use this chart

1 Mar 00:00 AEDT (28 Feb, 13:00 UT)
15 Mar 23:00 AEDT (12:00 UT)
31 Mar 22:00 AEDT (11:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

FEBRUARY HIGHLIGHTS

On 23 March, Earth passes through the plane of Saturn's rings, when the magnificent rings will be just a straight line across the centre of the planet. Our view will switch from the north to the south side of the rings, a rare event that persists until 2038. Unfortunately, Saturn is only five days past solar conjunction on the 23rd and unobservable. However, 45 minutes before sunrise on the 30th it will be low in the east and still showing a very narrow perspective, the rings tilted by only 0.3°.

STARS AND CONSTELLATIONS

The northern sky at twilight still shows the distinctive icons of the Winter Hexagon enclosing the bright stars of Taurus, Orion (plus his faithful hunting dogs) and Gemini. Evenings present the most southerly regions of the Milky Way stretched out overhead, with Crux (Southern Cross) and pointers, and then west to Carina and its gorgeous nebulae and star clusters. The mornings see the arrival of the distinctive winter asterisms of Scorpius and Sagittarius's teapot.

THE PLANETS

March opens with Saturn, Mercury and Venus very close to the western horizon but quickly lost to the twilight glow. The early evening sees Jupiter in the north, spending March close to bright Aldebaran. To its west is Mars, forming a triangle with Gemini's twin stars, the Red Planet being noticeably brighter than both and showing good colour contrast with yellow Pollux and white Castor. The morning sky is quite sparse until the end of March when Saturn arrives, rising around the start of dawn.

DEEP-SKY OBJECTS

The constellation of Vela, the Sails is our destination this month. North of the Eta Carinae region, just across the border lie two fourth-magnitude stars separated by 2.5°. The first is x Velorum (HD 86111) (RA 10h 39.3m, dec. –55° 36'), a double star dominated by a mag. +4.4 yellow primary with a mag. +6.1 companion a distant 52 arcseconds away. The second, due west, is J Velorum, a triple star. The dominating white member (mag. +4.5) has two companions: mag. +7.2 and mag. +9.2, separated from 'J' by 7 arcseconds (to the east) and 36 arcseconds (to the south), respectively. Next up, a brilliant globular cluster, NGC 3201 (RA 10h 17.6m, dec. –46° 25'). Visible as a small hazy patch in binoculars, a telescope reveals a bright (mag. +6.7), wide (7-arcminute) core, quite diffuse, with no central condensation. Under good seeing, a scattering of faint stars can be seen across its face.

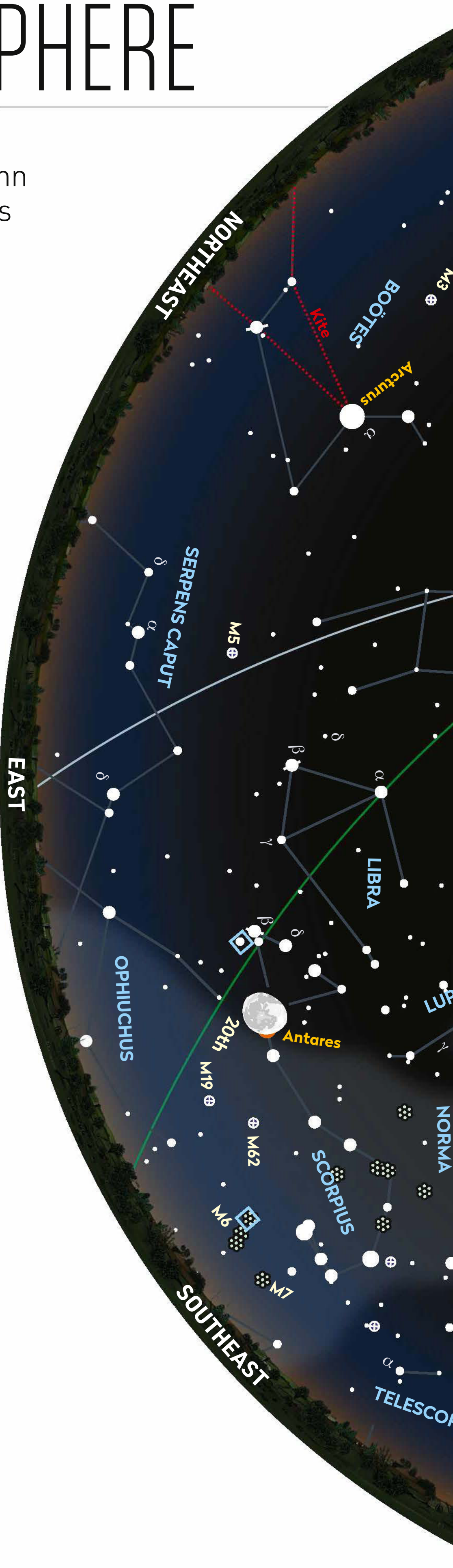
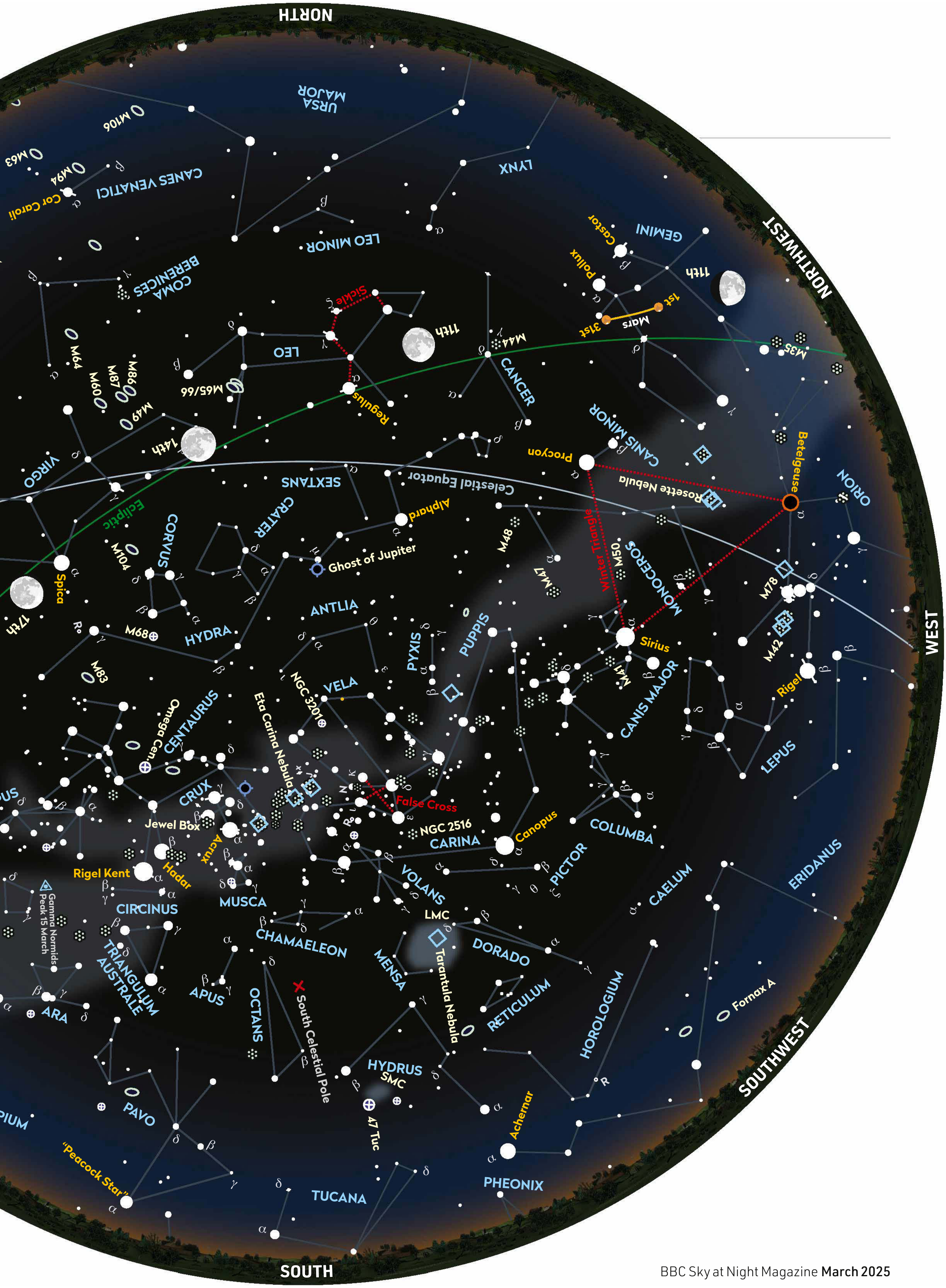


Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
URSA MAJOR
M106
M63
M94
Cor Caroli
CANES VENATICI
LYNX
LEO MINOR
GEMINI
Castor
Pollux
11th
Mars
1st
31st
COMA BERENICES
Sickle
LEO
4th
M44
CANCER
M35
M64
M60
M87
M86
M65/66
Regulus
M49
14th
VIRGO
CANIS MINOR
Procyon
Betelgeuse
ORION
Celestial Equator
SEXTANS
Rosette Nebula
Ecliptic
CORVUS
CRATER
Alphard
M48
M104
Ghost of Jupiter
Winter Triangle
M50
MONOCEROS
M47
Spica
17th
ANTLIA
M78
R
M68
HYDRA
PYXIS
PUPPIS
Sirius
M42
M83
M41
CANIS MAJOR
Rigel
NGC 3201
VELA
Omega Cen
CENTAURUS
Eta Carina Nebula
LEPUS
CRUX
False Cross
Jewel Box
NGC 2516
CARINA
Canopus
COLUMBA
Acrux
Hadar
Rigel Kent
Gamma Normids Peak 15 March
CIRCINUS
MUSCA
PICTOR
VOLANS
CAELUM
ERIDANUS
LMC
CHAMAELEON
DORADO
MENSA
Tarantula Nebula
TRIANGULUM AUSTRALE
APUS
OCTANS
South Celestial Pole
ARA
RETICULUM
HOROLOGIUM
Fornax A
HYDRUS
SMC
47 Tuc
PAVO
Achernar
"Peacock Star"
TUCANA
PHEONIX